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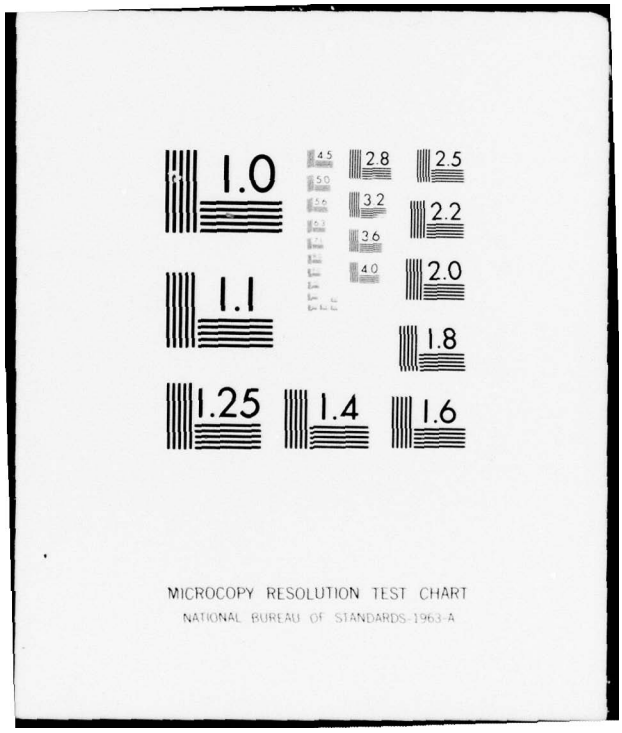
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THE JOHNS HOPKINS UNIVERSITY

DEPARTMENT OF PSYCHOLOGY

TECHNICAL REPORT – 6

CONFERENCING AND TELECONFERENCING IN THREE COMMUNICATION MODES AS A FUNCTION OF THE NUMBER OF CONFEREES

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Nine groups of 2, 3, and 4 students each, 27 groups in all, discussed stimulating topics in face-to-face conferences or in one of 2 teleconference modes: teletype and televoice. Each group used one of the three communication modes to solve a different problem on each of 3 successive days. The problems encouraged opinionated discussion and required the group to arrive at a consensus about how their fellow students felt regarding: (1) the priority of certain national issues facing the country today, (2) university budgetary considerations that affect the students' academic needs, and (3) priorities for

→ on these topics. → (cont on p 1473B)

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financial support to student activities on campus. Performance was assessed on a number of dependent measures: time to solution; the number of messages exchanged by the group; the total number of words used by the group; message length; the number of messages, and of words, communicated per minute; the number of messages, and of words, communicated by the average group member; the relative disparities among numbers of messages and words used by subjects within groups; and the amount of agreement between the consensus arrived at by the group and the results of a pool of the conferees' opinions on each discussion topic.

In general, an increase in group size (i.e.,) resulted in an increase in every group measure of communication. That is, the larger groups used more messages, more words, communicated faster, and exhibited greater relative variability among the numbers of messages generated by the individuals within groups than did the smaller groups. The only exception to this generalization is that 2-man groups generated slightly longer messages than did the larger groups. Groups as a whole and individuals within groups produced more messages and words in face-to-face conferences than did groups and individuals in either of the telecommunication modes. Communication rates were much higher in the two conference modes that had a voice channel, i.e., face-to-face and televoice, than in the teletype mode. Some practice effects were found, most notably in the reduction in the number of words used to arrive at solutions on successive days of the test.

Conferencing and Teleconferencing in Three Communication Modes as a Function of the Number of Conferees

Gerald P. Krueger

Based on a dissertation submitted to The Johns Hopkins University in conformity with the requirements for the degree of Doctor of Philosophy.

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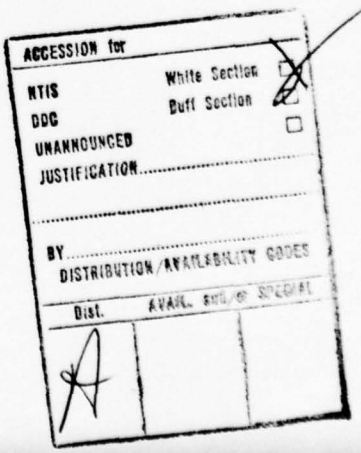

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Abstract

Nine groups of 2, 3, and 4 students each, 27 groups in all, discussed stimulating topics in face-to-face conferences or in one of 2 teleconference modes: teletype and televoice. Each group used one of the three communication modes to solve a different problem on each of 3 successive days. The problems encouraged opinionated discussion and required the group to arrive at a consensus about how their fellow students felt regarding: (1) the priority of certain national issues facing the country today, (2) university budgetary considerations that affect the students' academic needs, and (3) priorities for financial support to student activities on campus. Performance was assessed on a number of dependent measures: time to solution; the number of messages exchanged by the group; the total number of words used by the group; message length; the number of messages, and of words, communicated per minute; the number of messages, and of words, communicated by the average group member; the relative disparities among numbers of messages and words used by subjects within groups; and the amount of agreement between the consensus arrived at by the group and the results of a pool of the conferees' opinions on each discussion topic.

In general, an increase in group size resulted in an increase in every group measure of communication. That is, the larger groups used more messages, more words, communicated faster, and exhibited greater relative variability among the numbers of messages generated by the individuals within groups than did the smaller groups. The only exception to this generalization is that 2-man groups generated slightly longer messages than did the larger groups. Groups as a whole and individuals within groups produced more messages and words in face-to-face conferences than did groups and individuals in either of the telecommunication modes. Communication rates were much higher in the two conference modes that had a voice channel, i.e., face-to-face and televoice, than in the teletype mode. Some practice effects were found, most notably in the reduction in the number of words used to arrive at solutions on successive days of the test.

Introduction

Since 1970, Professor Alphonse Chapanis of The Johns Hopkins University has been directing a research program on human interactive communication. The experiment reported here was conducted as a part of that program.

Through a series of experiments already completed in the program (Chapanis, Ochsman, Parrish & Weeks, 1972; Chapanis & Overbey, 1974; Kelly, 1975; Ochsman & Chapanis, 1974; Parrish, 1973; Weeks & Chapanis, 1976; Weeks, Kelly & Chapanis, 1974) Chapanis and his students have demonstrated substantial progress in the systematic investigation of variables involved in dyadic person-to-person communication as it is mediated through various communication channels (Chapanis, 1973, 1975). These studies have contributed much to our basic understanding of how people naturally communicate with one another in a face-to-face setting and how they communicate through machine devices or electronic media when they are separated.

The latter kind of communication has come to be called "teleconferencing," the conduct of interactive communication between two, or among more than two, physically separated people via electronic media. In its most common form, teleconferencing includes all dyadic, or two-way, telephone conversations. However, the term "teleconferencing" is more commonly used to refer to communications involving more than two persons. The interactive nature of the communications among conferees distinguishes teleconferencing from such one-way, or non-interactive, forms of communication as radio and television broadcasts.

Genuine teleconferencing occurs among people in offices or homes that have telephone extensions and that involve more than two people at the same time. Of much greater practical significance, however, are the many businesses and government agencies that conduct weekly, and sometimes daily, centrally-arranged conference telephone calls among people located in various cities throughout the country. Not only do these calls provide speed and convenience in the conduct of regular meetings or in joint decision making ventures among groups of people who may be physically separated or scattered, but they also conserve personnel time and money by substituting for face-to-face meetings.

Teleconferencing, however, is not limited to the telephone medium. A variety of electronic devices allow groups of physically separated users to communicate via television, audio, teletypewriter, and telautograph (handwriting) linkages. Although such conference systems are less common than the ubiquitous telephone, they have recently been used in such diverse conference applications as telemedicine (NASA, 1974) and telebanking (Casey-Stahmer & Havron, 1973).

A new and unique form of group communication called computer teleconferencing is being investigated experimentally in a number of places

(Johansen,Miller & Vallee, 1974; Turoff, 1972). Among other things, computer-assisted teleconferencing systems provide geographically dispersed groups with immediate printed records of their communications and with facilities that allow messages to be retrieved en masse or selectively, e.g., by date, sender, or topic.

The ultimate widespread acceptance of all teleconferencing systems depends on a number of considerations, many of which are directly related to the user's perception of the system's effectiveness. These considerations involve a large number of psychological variables associated with human interactive communication processes. Many of these have been studied for dyadic conversations, and many yet remain to be studied. However, there have been almost no attempts to study systematically how these variables change as the number of conferees changes. As an extension of the Chapanis research program, this experiment has for the first time studied systematically a set of conferences and teleconferences involving 2, 3, and 4 conferees.

The Problem

This experiment was designed to study interactive communication in groups of 2, 3, or 4 conferees as they conversed in one of three communication modes to arrive at consensus solutions to realistic group decision making problems. Although the primary goal of the research was to discover how an increase in the number of conferees changes the nature of conferences, the study was also designed to compare performance with three different modes of communication on three successive days, with three different problems, and with various combinations of these main variables.

Since the scanty literature available provided almost no basis for predictive hypotheses, I formulated very few. I hypothesized simply that as the size of the conference group increased, so too would the amount of communication and the problem solution time.

Three different modes of communication were investigated: face-to-face, televoice and teletype. Face-to-face conversation is usually accepted as the standard against which to compare performance in mediated modes of communication. In the televoice mode, a close analog to "hands-free" telephoning, conferees cannot see each other but have the speed, flexibility and full range of expression that can be conveyed by voice. In the teletype mode, conferees can neither see nor talk to each other. However, this mode provides a printed version of the transactions. The televoice and teletype modes are representative of teleconferencing channels that are readily available, are relatively inexpensive, and are in use now.

The experiment was also designed to study learning effects, that is, to discover whether conferees become more or less efficient at teleconferencing as they gain experience working together as a team and as

they acquire experience with a particular communication mode. Two previous studies in the Chapanis series (Chapanis & Overbey, 1974; Kelly, 1975) found practically no learning effects by dyads. One possible explanation of those negative findings is that subjects were confronted with a new type of problem on successive days. It is possible, therefore, that each new day presented a new learning situation. In this experiment the three problem solving tasks were much more similar in structure than were those used in the earlier studies. I hypothesized that early group learning effects would be demonstrated by the third conference session.

Although not a variable of primary interest, problems was the fourth main variable in the study. Since the three problems were designed to be similar in cognitive structure, I anticipated few communication effects due to problems per se.

Just as important as the main effects were a variety of possible interactions. Although I expected to find some interesting ones, I started with no specific hypotheses about particular interactions.

The dependent measures can be grouped into four classes: the time taken by the groups to complete the tasks, communication output (both verbal and typewritten), the quality of the problem solutions, and questionnaire opinion data. The first three classes of data describe quantitatively some group communication processes while the questionnaire elicited subjects' qualitative descriptions of these processes.

Review of the Literature

Man has engaged in various forms of interactive communication probably ever since he evolved into humanoid form. The most common form of interactive communication is that conducted face-to-face. However, even in the early years of his history man learned to extend his ability to communicate through both time and space by using such aids as non-speech sounds, smoke signals, drawings and signs, and then eventually handwriting and printing. Much more recently the telegraph, telephone, radio, television, computer and satellite have dramatically boosted man's abilities to communicate rapidly and over great distances. Indeed, modern systems enable man to communicate with his fellow man over distances as great as a quarter of a million miles, i.e., from the earth to the moon, and with his machines over as great as 50,000,000 miles, i.e., from earth to the planet Mars. "Telecommunications" is the label for an entire industry that has evolved to link us together through electrical and electronic devices.

In the quickened pace of the 1970's the proliferation of telecommunication devices, their availability, and their many impressive successes, has resulted in our taking most of these devices for granted. It is important to note, however, that while most of the basic technology that

underlies telecommunication devices, such as electricity, transistors, cathode ray tubes, telephone, radio and television transmitters and receivers, was well advanced before the 1950's, its availability was in fact not widespread until long after World War II. For example, although most city and urban dwellers in the United States enjoyed electric conveniences by the late 1940's, most rural dwellers did not. In 1950 only 45% of the farms in the United States had electricity; but by 1960 this number had grown to nearly 97% (Rixse, 1960). Due to shortages as an aftermath of World War II, only 38% of farms had telephones in 1950; and only 60% of all farms had telephone service by 1959 (Weitzell, 1960).

Due in large part to the invention of the transistor in 1948, radio usage soon became widespread even in areas where electricity was not available. In 1959 there were 4,142 radio broadcasting stations in the United States alone (Beaty, 1960), and it is estimated that there were 156 million radio receivers in the United States by the year 1962, almost one for every man, woman and child (Fabre, 1963). In the 1950's television was still in its infancy. However, by 1962 there were 59 million television sets in use in North America (Fabre, 1963).

In the early 1950's computers were also new communication tools. However, the growth in the number of computers and in the uses to which they have been put during the past twenty-five years is both dramatic and impressive. The many different uses of the term "computer" make qualifications a necessity for any reported numbers of such machines. Conservative estimates place the number of digital computers well into the hundreds of thousands in the United States alone. As for their applications, Chapanis (1971) suggests that it would probably be more economical to list those areas in which computers have not been applied than it would be to list those in which they are applied.

Since the early 1960's research and development activities by government aerospace and military agencies, as well as by the commercial telecommunications industry have also resulted in a rapid growth of satellite technology and usage. Some direct effects of satellite communications on our daily lives are the live television transmissions we now receive from all regions of the earth, from astronaut space stations, and from weather satellites circling our globe.

In summary, the decades of the 1950's, 60's and 70's have produced a communication "explosion." The proliferation of sophisticated devices and services during these years has resulted in a tremendous increase in: (a) person to person communications, (b) mass media public communications through radio and television broadcasts, and (c) man-machine communications best exemplified by the integration of satellite and electronic computer technologies in the design of modern teledata systems. Moreover, there is no evidence that advances in communications technology will taper off soon. Such developments as world wide automatic digital network teleprocessing, automatic voice network switching systems, improved

communication satellites, and Laser communication systems promise to spread the waves of the communication explosion more thoroughly around the globe and even into the far reaches of our universe. Indeed, recent technological advances have been so great that they have prompted industry spokesman Stony (1970) to make such statements as:

> The communications and data processing horizons that are opening in front of us are limited only by the competence of our own thought processes to apply this fantastic capability to our needs. The technology is there. At long last communications-electronics has caught up with, and passed, the demands of the user. The problem now is for the communicator technician to help the customer to use what we have the capability to build, and to avoid the overlap and duplication of systems that make it prohibitively expensive (p. 2).

An important point implicit in Stony's remarks is that technological advances have been thrust upon us so quickly that they have outraced our understanding of how best to use them now and in the future. Our record in adapting these capabilities to our needs has not been as good as we would like. A lengthy report of a committee of the National Academy of Engineering (Panel on Telecommunications Research, 1973) concludes that:

> At the man-machine interface, we understand the machine better than the man. There are both hardware and software design issues, but software issues are dominant and growing. We have almost no predictive design technology in this area (p. 50).

Frequently industry has acted in the absence of psychological design criteria because behavioral scientists, especially psychologists, did not attach much importance to the topic of communication before 1949 (Chapanis, 1971) and therefore did not produce such data. However, the last two and one-half decades have produced a significant amount of research on the psychological aspects of "human communication." What has it told us and where do we stand?

The Past Twenty-Five Years

Behaviorally oriented research on the multifaceted topic of human communication has varied greatly in both scope and breadth. Still, several identifiable trends emerge during the past twenty-five years. Each has followed from the basic orientations of a few writers and researchers around the time of 1950.

Perhaps one of the most influential lines of research has been directed towards attempts to fit human communication into the mathematical model of information theory formulated by Shannon (1948) and Shannon and Weaver (1949).

In the 1950's the topic "communication theory" was largely synonymous with the narrowly defined and highly technical interests of "information theory." Initially, the goal of the information theorists was equipment bound, i.e., to measure the amount of information that could be transmitted by messages over channels in communication systems like telephones or radios. Then came many attempts to apply information theory to the more psychological aspects of communication, often under the label of "communication theory." Johnson's bibliographies (1967, 1970), for example, list 942 references on the use of information theory in psychology between the years 1948 and 1970. Many of these works cite the Shannon papers as their starting points.

Information theory worked rather well when it was applied to communication equipment, but its application to the psychological aspects of communication served mainly to underscore the need for a more behaviorally oriented, synthetic theory of human communication (Sereno & Mortensen, 1970). Numerous books, scientific journals, professional associations and academic curricula now use the term "communication theory" to refer to the interdisciplinary, behaviorally oriented field of research dealing with the constituent processes of human communication.

Other major research trends which began around 1950 were less mathematically based and concentrated more on the variables of interpersonal communication. Bales (1950, 1955, 1970) developed his now classic technique for scaling interpersonal relations among people by studying their communications in groups. Research on the cooperative, competitive, and persuasive aspects of communication in interpersonal bargaining probably originated with the work of Deutsch (1949), and was continued by Hovland, Janis and Kelley (1953) and by Krauss & Deutsch (1966). The study of psychological variables in network arrangements began with Bavelas (1950), Leavitt (1951) and Shaw (1954) and was continued through the middle 60's (Davis & Hornseth, 1967). The study of facial, gestural and body communication also came into its own in the 1950's (Birdwhistell, 1952) and was followed by investigations into the more subtle areas of proxemics and communication by intra-body distance (Hall, 1959).

Beckenbach and Tompkins (1971), Berlo (1960), Bettinghaus (1973), Cherry (1957), Miller (1973), Lin (1973), Parry (1967), Schramm (1963) and Wiener (1948) are the principal authors who have written books about the diverse aspects of human communication. By 1961 the field of research on communication had become large enough to support its own scientific journal, the Journal of Communication. More recently deSola Pool, Frey, Schramm, Maccoby and Parker (1973) have edited a comprehensive handbook on the subject. Despite all this activity, Sereno and Mortensen's (1970) assessment is that the field of human communication research has not yet established many sharply defined boundaries or domains and that the field still lacks theoretical integration. Even more important is that technological innovations have followed one another with almost breathtaking rapidity without corresponding advances by behavioral scientists on how that technology could be best made to serve man.

Klemmer (1973) put out yet another call for psychologists to bridge the gap between the technological advances and our level of understanding of interpersonal communication. He said that the work of the leading psychologists, sociologists and others studying interpersonal communication has had little impact on the engineers who plan new communication systems. By way of the following example he points out that the job still remains to apply the psychology of communication to the design of modern communication systems.

> A natural assumption has often been made when considering new telecommunications systems. That assumption is that face-to-face is the ideal method of interpersonal communication and so new systems should tend to approximate face-to-face. Telephone is closer to face-to-face than telegraph and PICTUREPHONE® is closer than telephone. Color, high fidelity and three dimensions would be closer still.
>
> Even if one accepts the intuitive premise that face-to-face is optimum communication there is still a large question about which dimensions of approximation are most important--most important on a cost/utility basis. Laboratory experiments and field trials are required here for intuition does not provide dependable answers. (Klemmer, 1973, p. 5)

In the 1960's the PICTUREPHONE® was introduced in several cities in the United States. That was a very costly failure. Although there were probably many factors contributing to the failure of PICTURPHONE® one apparent misjudgment was the decision to market it in advance of the collection of appropriate data on the psychological variables involved in interpersonal communication via combinations of video and audio channels.

Psychology did, of course, respond eventually to the pressing need for behavioral research data that could be related to communications technology. However, it was not until about 1970 that several research programs were instituted to study how people naturally communicate with one another and how normal patterns of communication are affected by the devices through which people can converse. The principal research centers are the Communications Studies Group (CSG) in London, The Johns Hopkins University's Communication Studies Laboratory in Baltimore, the Wired City Simulation Laboratory at Carleton University in Ottawa, and the Human Factors Department at the Bell Laboratories in Holmdel, New Jersey.

Initial efforts of the CSG, described later in this paper, were completed in 1973 (Communications Studies Group, 1973a & 1973b). The work at Carleton is just getting underway (Coll, 1973). The Bell Laboratories continue to provide excellent research on interpersonal communication behavior (Klemmer, 1973), and the research conducted at Hopkins has provided much leadership in the field (Chapanis, 1975). It is the research at Hopkins which sets the stage for the research reported here.

Human Interactive Communication

Chapanis describes interactive communication as the kind in which the participants actively exchange information, ideas, and hypotheses through messages that are intended to serve some function, for example, to solve a problem, to persuade someone to take some action, or to engage in psychotherapy. Chapanis distinguishes interactive communication from those forms of communication that may be described as unidirectional. In unidirectional communication the recipient of information is not an active contributor to the communication process. Newspapers, books, radio, television, advertisements and even a great many lectures are examples of unidirectional communication. In interactive communication, a given message is determined in part by the content of prior messages from all participants in the communicative process. Examples of interactive communication are telephone conversations, conferences, seminars, debates and workshops. Chapanis (1974) asserts that his distinction between unidirectional and interactive communication systems is essential to a genuine theory of communication.

In describing human interactive communication Chapanis (1974) has listed at least eight major variables that must be included in a detailed model of it. Without elaboration, they include:

1. The number of communicators in the network.

2. Personal characteristics of the communicators.

3. The balance or match between the communicators, e.g., in status or skills.

4. The communication channels available to the communicators, e.g., face-to-face, voice, closed-circuit television, teletypewriter.

5. Restraints imposed by the communication channels, e.g., voice fidelity, interruption capabilities.

6. The language in which communications are carried out.

7. The purpose for which the communication is being carried on, e.g., to solve problems, to instruct, to persuade.

8. The particular network of connections between the various communicators in the systems.

Surprisingly little is known about the effects of most of these variables individually or the relationships that hold between them. The Chapanis research program has been systematically investigating various hypotheses about the eight variables listed above.

Initially, Chapanis's experiments have focused on cooperative problem solving in which two-person teams communicated in a variety of

communication modes: face-to-face, handwriting, teletypewriting, telephone, closed-circuit television and combinations or mixes thereof (Chapanis, Ochsman, Parrish & Weeks, 1972; Chapanis & Overbey, 1974; Ochsman & Chapanis, 1974; Weeks, Kelly & Chapanis, 1974). The findings from these studies, summarized by Chapanis (1975), are both extensive and rich and provide data essential to the development of a model of interactive human communication.

Briefly, some of the more significant findings are:

1. Oral modes of communication, voice and face-to-face conversation, allow for much faster problem solving than do hard copy modes of communication, handwriting and teletypewriting. However, oral modes are much more wordy than hard copy modes. That is, oral modes are characterized by many more messages, many more sentences, many more words, and many more unique words, but lower type-token ratios (Chapanis, Ochsman, Parrish & Weeks, 1972; Chapanis, Parrish, Ochsman & Weeks, 1977).

2. Face-to-face communication is not appreciably better than simple voice communication for factual problem solving (Chapanis, 1973).

3. Natural interactive human communication in any mode is characterized by its extreme grammatical unruliness (Chapanis, Parrish, Ochsman & Weeks, 1977).

4. Although interruptions in normal human communication are so common that it seems natural that they should, or must, serve an important communication function, empirical tests show that interruptions are much less important than one might at first suppose (Chapanis & Overbey, 1974).

5. Typewriting skill per se has no appreciable effect on communication in a teletypewriter mode (Weeks, Kelly & Chapanis, 1974).

More recently, Weeks and Chapanis (1976) completed a study extending the work into the areas of different types of problem solving tasks, and Kelly (1975) studied the effects of limiting the size of the vocabulary that subjects were permitted to use.

Conference Size as a Variable

So far all of the communication experiments in Chapanis's laboratory have involved only dyadic interactions. In addition, very little research published elsewhere is directly relevant to teleconferencing with differing numbers of conferees. A review of the applicable literature follows.

The IDA Studies. From 1963 through 1965 the Institute for Defense Analyses (IDA) and several subcontractors conducted a series of teleconferencing studies under the sponsorship of the Advanced Research Projects Agency (ARPA). The purpose of the program was to examine the procedural and technical arrangements required to permit key personnel who spoke different languages, and who were at separate locations, to conduct effective conferences through such media as telephones, teletypewriters and television, either alone or in combination (Bavelas, Belden, Glenn, Orlansky, Schwartz & Sinaiko, 1963). In addition to equipment surveys and studies of language translations, the IDA work included a series of short in-house experimental studies that investigated alternative conference configurations (Sinaiko & Belden, 1965).

Although the first IDA conference study was exploratory, it tested 14 experimental conditions, each consisting of a different 5-station conference configuration. It identified many of the variables of importance in teleconference design but answered very few questions conclusively.

Two of the 14 conditions involved conferences via telephone links only, in English, one with a conference chairman and one without, and both with an open party-line network. Nine of the conferences were by teletype only. Of the 9 teletype conferences, four were in English only; the other 5 were in both English and French with simultaneous 2-way translation through the use of interpreters. Four of the 9 teletype conferences had a Y network in which all conferees had to transmit to a nonparticipant chairman at the center of the net. The chairman then rebroadcast each message to all stations via tape relay. In the other 5 conditions a party-line common circuit was used. Variations within these party-line circuit conditions included (a) the assignment of conference chairmen, each with different roles, e.g., one who was allowed to act as a participant, and another with the prerogative of modifying and editing, (b) subdivision of the net into two subnets, and (c) serializing transmissions sequentially from any station to all others in turn.

The remaining 3 of the 14 conferences were all conducted in English, without chairmen, and over combined party-line teletype and telephone media. In one there were two private phone lines; in another the participants could telephone each other selectively; in the third there was a teletype subnet of three and a telephone subnet of three, with one participant belonging to each subnet.

In each of the 14 IDA conferences there were four principals (subjects). Depending upon the experimental condition these principals were assisted by translators, teletype operators and conference chairmen. In all conditions the subjects' task was to participate in a negotiation war game called SUMITT-II (Kidd, 1963), in which each principal represented one of four countries in a unified confederation allied against a common enemy. Participants' actions during fixed time cycles consisted mostly of contributing military units in response to requests for assistance levied against the confederation.

The war game was played only once in each of the 14 conference configurations, that is, each condition had a single replication. Unfortunately, the results of these 14 miniature experiments were never expressed quantitatively. Although time and motion type records of who said what to whom were collected, the researchers placed more emphasis on the results of informal debriefings of the subjects and upon their own direct observations of the many conference arrangements (Sinaiko & Belden, 1965). Many subjects thought that being able to respond immediately was a desirable feature of telecommunication systems except in cases where the principals needed time to think before responding. The subjects also said that they preferred the telephone to face-to-face conferencing for negotiation, but that they preferred the teletype to the telephone if they wanted to take a firm position and maintain it.

Two other IDA single replication conference studies are described by Parsons (1972). In one, two 4-man teams carried on a labor-management negotiation over split-screen television. The television monitor allowed each team to see both the chairman of the opposing team and its own chairman. The only result mentioned by Parsons is that the subjects found the split-screen television distracting and objectionable.

In the last miniature IDA experiment twelve persons sat at their desks in three different cities and were linked together in a party-line telephone conference. Their task was to agree upon a date and place for a three-hour meeting. Each participant had a calendar that listed his own busy and free dates for the month. The times on all calendars were so arranged that only a single half-day period in the month would be available for all twelve participants. Although none of the participants termed the telephone conference very efficient, they thought it was at least "reasonably successful." All agreed that there had been a chairman but disagreed on who it was and on the nature of the chairmanship.

Kite and Vitz (1966) conducted a study at Stanford University on an IDA subcontract. Sixty-nine groups of students, ranging in size from 2 to 6 students each, played a negotiation game under varying conference conditions which compared face-to-face (12 groups), telephone (35 groups) and teletype (22 groups) communication.

In their experiment, Kite and Vitz used several types of telephone networks, including one in which an intercom allowed only one person to speak at a time. In the teletype condition subjects dictated messages to a typist who carried the messages to the experimenter, who in turn delivered them to the other players. In addition, three types of communication network were involved: party-line, chairman-controlled and automatic successive broadcast. The game, called "Crisis," ran for five trials or cycles of negotiations among players in each conference.

Although Kite and Vitz present no statistical analyses of their dependent measures, they report little difference between telephone and

face-to-face negotiation behavior, but large differences between telephone and written negotiations, the latter taking more time, tending to be more rigid, and being susceptible to the development of intransigent positions. Unfortunately, in their own words, their research was characterized by a "relative laxity of experimental control rendering a quantitative analysis of the data inappropriate and dictating a minimal presentation of such data" (Kite & Vitz, 1966).

In an experiment by Bailey (1964) four 3-person groups and four 7-person groups were netted in successive sessions in the party-line (continuous access) and point-to-point network arrangements. Their task, like that of the 12-person group mentioned above, was to schedule a joint meeting. Not surprisingly, the larger groups took significantly longer to schedule their meeting. The party-line network became increasingly advantageous as group size increased, although the networks by themselves did not produce different effects.

Bailey and Jenny (1965) examined the functions of a conference chairman in a successive broadcasting situation. Eight conferees included a chairman who controlled the access of the others to the party-line by means of a console. In one condition he manned the console himself and in another he was remotely located and directed a console operator by telephone; in each he had an assistant to maintain a list of conferees waiting to speak. The tasks required coping with different crisis problems in a simulated public health organization. The console arrangement did not yield a clear-cut difference in message generation rates. However, long speeches in the terminal phase of a conference were related to dissatisfaction with the chairman as noted in post-conference questionnaires.

Parsons (1972) cites an experiment by Kidd (1965a) which compared 16-person groups to 8-person groups in problem-solving conferences. The experiment compared continuous access with successive broadcast arrangements, but Parsons reports only that Kidd found successive broadcast to be more advantageous for 16-man than for 8-man groups.

Another experiment by Kidd (1965b) also compared continuous and successive access; the latter had two variations. In one, any would-be speaker requested access when an active speaker had finished. In the other, requests could be made at any time and requesters were placed in waiting lines or queues. Each of three party-line methods were used for each of three sizes of conferences, 8, 14, and 20 conferees, resulting in 9 different experimental conditions. Nine sessions, one per experimental condition, were held. Among the many measures were ratings of (a) conferees' attitudes toward the chairman's control of the conferences, (b) the chairman's attitude toward the network, (c) conferees' attitudes toward the chairman, and (d) conferees' attitudes toward the conference. Other measures included average length of statements and the distribution of speaking time among the conferees. Although Kidd's research seems to be directly related to things reported here, I have been unable to obtain

detailed documentation of his work. Parsons (1972) indicates that Kidd unfortunately reported no significance statistics.

There are other reports of teleconferencing studies by IDA and its subcontractors (Parsons, 1972). However, they are less directly relevant to the research reported here. Since the overall objective of the IDA research was to explore a variety of issues related to teleconferencing, many of the experiments were not conducted in accordance with the principles of rigorous experimental design. The researchers themselves called their work a set of "indelicate experiments" (Sinaiko & Belden, 1965; Kidd, 1965) characterized as having the logic of experimental design which permits orderly observation of some phenomenon but which does not allow the usual emphasis on statistical analysis.

The "indelicate experiments" of IDA served their purpose: to answer high level governmental questions in a hurry. Without in any way detracting from that work, the research reported in this paper constitutes a study of some very similar teleconference settings but also adds rigorous experimental controls, presents quantitative data, and in general attempts to be substantially more "delicate."

Communications Studies Group. Another program that has produced a considerable amount of research related to interpersonal communications is that of the Communications Studies Group (CSG) in London. The work of the CSG has included industry surveys, analytical and field studies, and laboratory experiments to compare the effectiveness of a number of person-to-person communication systems for a variety of communication tasks, and to investigate the likely impact of future telecommunication systems on office location and business travel patterns (Communications Studies Group, 1973a).

CSG has already conducted over 20 experiments in which about 2000 civil service personnel have taken part. Although different media have been used, teletypewriting was never one of them. For some tasks performance was measured objectively, for others experimenters used less rigorous methods to determine whether the medium of communication had a qualitative effect on the outcome. Questionnaires and interviews were typically used to obtain subjective data on the participants' perceptions of one another, their impressions of the effectiveness of their performance of the tasks, and their feelings about the systems they had used. Most of these experiments were done with two participants and only a few involved as many as three or four subjects at a time (Communications Studies Group, 1973b). Unfortunately, data have been published on only a few of these larger conferences.

In a study of the formation of coalitions, Williams (1976) had four-person groups communicate either face-to-face or over one of two telecommunication systems: a closed-circuit television system, or an audio system (microphones and speakers). For the telecommunication groups

there were two subjects at each of two nodes and in the face-to-face meetings two pairs of subjects sat on opposite sides of a conference table. The group's task was to hold a brainstorming discussion to produce a number of ideas for ameliorating the "Problems of Travelling in Britain."

Williams found that in both audio and television systems, subjects showed a significant bias towards supporting the person at the same node of the telecommunications link. In addition, in the audio condition only, subjects showed a significant bias towards disagreeing with the ideas of people at the other end of the link and rating those distant people less favorably than their near-end colleagues.

In the only other CSG report on groups larger than two persons, Champness, Short and Davies visited the Bell Telephone Laboratories where they ran a study using over 200 subjects in conference discussions of four people each (Communications Studies Group, 1971). Three media were used: face-to-face, closed-circuit television and telephone. The conferences were all of the bargaining type. Bargaining "victories" tended to be greater via the audio (telephone) medium than through face-to-face discussion. There was also more simultaneous speech during video (closed-circuit) discussions than in discussions conducted with either of the other media.

Of the more completely documented studies of dyads, Short (1971a, 1971b, 1971c) described a series of three bargaining experiments in which pairs of subjects worked at simulated wage negotiation tasks in telephone and face-to-face conditions. When an imbalance between the two communicators was created by giving one subject a stronger case to argue, the person with the stronger case was more successful in the telephone condition than the face-to-face condition (Short, 1971a), a finding which essentially replicates that of Morley and Stephenson (1969). On several indices of performance no media differences were found when the competitors had equal starting positions (Short, 1971b). When one subject was allowed to choose his own order of payoff priorities among the items on the negotiation list, and his opponent was given a payoff list the inverse of it, no reliable differences between face-to-face and closed-circuit television conditions were found (Short, 1971c).

Davies (1971a, 1971b) also used pairs of subjects conversing face-to-face or by telephone to reach mutually agreeable solutions to a concept attainment task. There were no significant media effects on time to solution, solution scores, or agreement on the solution. In the first experiment, however, he did find that the number of lines of transcript (speaking time) was significantly greater face-to-face than over the telephone, but this media effect was not replicated in the second study.

After they had held six minute discussions face-to-face, and over audio and closed-circuit television systems, Champness (1973) had pairs of subjects rate the media of communication on semantic differential scales. He found media differences for aestheticism, evaluation, and privacy,

indicating that subjects' attitudes toward their media should be taken into account in explanations of differences in laboratory studies.

The CSG work was both diversified and comprehensive. However, none of it has systematically compared various sizes of conference. Nor has the CSG ever studied communication via teletypewriter.

Network studies. Studies on communication networks (Bavelas, 1950; Leavitt, 1951; Shaw, 1954) have systematically varied the pattern of communication restrictions among five individually isolated members. Group problem solving in such communication networks as the "circle," the "chain," the "wheel," and the "Y" have generally allowed the members to communicate with each other only by written messages. Not all members could communicate with all other members, and in most cases members could communicate with each other only through one or more intermediaries. Typical tasks required the group to identify a common symbol among those distributed to members, or to select the best poker hand from the combined cards held by all members.

Bavelas developed an index of centrality to describe any one person's position within the communication net. A high index indicated that the individual was allowed to converse directly with a large number of people in the net. Mean centrality was greatest in the wheel and decreased in the following order: Y, chain and circle (Leavitt, 1951).

In a study using the common symbol identification task Leavitt (1951) gave each subject five different symbols out of a possible set of six. The task was for the entire group to discover the one symbol held in common by all five members. Records were kept of speed, errors, and number of messages. At the end of the experimental session the subjects were given a questionnaire before they talked to each other.

Leavitt found that the different communication nets did not differ significantly in the average time it took to solve the problem. However, behavioral differences among communication patterns and among the individuals' positions within the various nets related consistently to the same progression of the mean centrality indices. Communication in the wheel was least erratic, produced the highest task performance, required relatively few messages to solve the task and was organized with a definite leader, but was not very satisfying to its members. The circle on the other hand, resulted in the most active, erratic, unorganized and leaderless communication, but was most satisfying to its members. The chain and the Y were more like the wheel than like the circle and produced behavior patterns between these two extremes. In general, for all networks, the member in the most central position became the leader and was more satisfied with his job than were the occupants of peripheral positions.

Shaw (1954) conducted an experiment that was similar to Leavitt's but that required the subjects to do simple arithmetical computations.

Shaw found that with these slightly more complex problems the less centralized circle was superior to the wheel.

Only a few studies of voice communication networks have been reported. Lanzetta and Roby (1956) reported experiments in which visually isolated group members of 3-man teams communicated freely over telephones or intercoms while working on an aircraft flight instrument setting task. However, these groups did not constitute networks in the sense of physically patterned communication channels.

Davis and Hornseth (1967) assigned five-person groups to wheel, circle and completely-connected (Com-Con) nets and had them communicate, no more than two at a time, in the voice (intercom) mode to solve "eureka" problems. They found that Com-Con produced the most discussion and the wheel the least. On the average, network conversation was less uniform or less equalitarian than would be expected from the hypothesis that each person was equally likely to speak. Lastly, there were no clear differences among networks in the proportion of solutions achieved or in the mean time required to arrive at an answer.

Davis and Hornseth concluded that results of voice network studies do not support findings from experiments using written messages. In their view discussion over voice channels is so effortless that communication structure per se has a negligible effect on performance. With voice channels, an efficient operating pattern may be achieved with ease and speed no matter what the physical arrangement of the network.

Much of the work on communication nets has been reviewed by Glanzer and Glaser (1961). Despite some conflicting results, network studies generally agree that the type of network exerts a strong influence upon group members in the area of total activity, satisfaction of individual participants, emergence of a leader, organization of the group and the efficiency of collective performance. However, the bulk of this research is not very relevant to the experiment reported here since a completely connected net was used throughout. In any case, Parsons (1972) seems to feel that there is little evidence that the network studies helped to solve any key practical problem of modern intercommunication, especially regarding the concerns of individuals who are physically separated from each other.

Group dynamics. Although findings from studies of group dynamics might appear to have relevance for all interactive problem solving situations, that is not really the case. Most of the voluminous literature on group dynamics (see Strodtbeck (1973), for example) is concerned with variables that are of little or no interest to this experiment.

However, several relevant findings in the group dynamics literature are concerned with the comparison of individual performance with group performance in group problem solving discussions. In a study of

"brainstorming," for example, Taylor, Berry and Block (1958) have shown that individuals produced a greater number of ideas, and ideas that were more original and unique, than did groups. The works of Stoner (1961) and Wallach and Kogan (1961) served as the stimuli for a considerable amount of research on the "risky shift" phenomenon. In general, group discussion appears to influence private opinions, as well as group decisions, toward greater risk. However, the "risky shift" research has also been severely criticized by Cartwright (1973) and some of the most consistent findings must be accepted only with qualification.

The question "Do individuals or groups make better decisions?" has been tested under a wide variety of experimental conditions (see for example Holloman & Hendrick, 1971; Kelley & Thibaut, 1954; Lorge, Fox, Davitz & Brenner, 1958). Most of this research also requires some qualification and some of it is quite conflicting. If a single generalization must be drawn it is that groups are superior to individuals. The assertion, although usually qualified, that "two heads are better than one" agrees with our common sense feeling that the probability of reaching a "good" decision is increased by having more people participate in making the decision.

Learning effects. Two previous studies in the Hopkins series (Chapanis & Overbey, 1974; Kelly, 1975) attempted to demonstrate group learning effects by teams which met together in conferences on more than one occasion. Both of these involved only two-person teams.

Chapanis and Overbey (1974) had teams of male college students solve four rather diverse problems, one on each of four successive days. The assignment of communication channels to the subjects also was mixed over subsequent days of the testing. Practice effects were almost entirely absent.

Kelly (1975) had teams of college females solve three problems while using a single communication mode, teletypewriting. However, the problems which the teams solved on each subsequent day were still quite different one from another. He reported that there was little systematic change in the subjects' behavior or performance across the three days of testing that could be attributed to any kind of learning.

Since both of these studies confronted subjects with a new type of problem on successive days, it is possible that each day's test presented the teams with a new learning situation. There are no reports in the literature on attempts to study conference group learning effects on groups larger than two persons. This variable of interactive human communication is, therefore, as yet virtually unexplored.

Conclusions from the Literature

From the literature one can see that during the years 1970-1976 our understanding of the communication behavior of dyads in conferences

and teleconferences has increased significantly. There are, of course, many interesting variables yet to be studied on dyads. However, we can also see that at this point our understanding of the communication processes of larger conference groups is even more inadequate. Indeed, there are no reports of systematic studies of conference groups of varying sizes. Today's technology allows us to provide teleconference facilities for large numbers of people who are physically apart. Yet, we know very little about how the telecommunication of groups consisting of more than two people is affected by the media over which they converse. Furthermore, we know little about group learning processes when a group meets together in conferences or teleconferences on more than one occasion.

Method

Subjects

The subjects were 81 undergraduate male students at The Johns Hopkins University. Each subject took part in one experimental session on each of three different days. Subjects were paid an hourly wage for their participation, a bonus for completion of the series of three sessions, plus a share of a second bonus payment based on the correctness of the group's solution to each of the three problems.

Communication Modes

In this experiment the term communication mode describes a particular combination of methods and devices used to convey information in a particular communicative situation. A communication channel refers to a specific pathway over which the information travels (Weeks, 1974). A mode therefore may have one or more channels. For example, the mode of ordinary face-to-face conversation includes both a visual and a voice channel of communication.

Three communication modes were tested in this experiment: teletype, televoice, and face-to-face conversation. Teletype and televoice are representative of those modes which are, or might be, used for telecommunication, teleconferencing, or even man-computer communication. The face-to-face mode is not a telecommunication mode per se. However, telecommunication modes are generally regarded as substitutes for face-to-face communication. In this sense face-to-face communication can be considered the baseline mode.

Teletype mode (TTY). In the teletype mode, each subject was in an individual room equipped with a teletypewriter. The subjects held their conference by typing messages to one another.

Televoice mode (TELEV). In the televoice mode each subject was in an individual room and was able to communicate with the other members of

his group only over a microphone and speaker system. When any subject spoke, his voice was transmitted to all the other members of the group. This conference situation resembled an ordinary conference telephone call except that it was a "hands-off" operation, that is, subjects did not have to hold a telephone handset.

Face-to-face mode (FTF). In this mode, subjects conducted their conferences sitting around a table (1.83 m X 2.44 m). They were able to see and hear one another across the table in an unobstructed manner.

Some comparisons among the modes. One important difference between the teletype mode and the modes that contain a voice channel concerns the freedom of a "speaker" to interrupt those with whom he is communicating. In the modes using spoken communication, interruptions were easily made by merely "speaking up," and, even while being interrupted, a speaker could continue to speak until he had completed his message or until he decided to stop talking. The latter behavior resulted in frequent episodes of overlapping or simultaneous speech by two or more conferees.

On the other hand, subjects who communicated via teletypewriter had to follow a somewhat more rigid set of rules for interruptions. A depression of the circuit control button (see Apparatus) abruptly cut off a message being typed and required the interrupted communicator to regain control if he wanted to complete his message or to continue holding the channel. Overlapping, or simultaneous messages were, of course, impossible.

Apparatus

Laboratory rooms. Four adjacent laboratory rooms in the Psychology Department at The Johns Hopkins University were used for tests in the televoice and the teletype communication modes. A room (4.57 m X 7.62 m), built especially for conference research in the Department of Social Relations at The Johns Hopkins University, was used for tests in the face-to-face mode.

Teletype equipment. Each subject had one teletype machine (Teletype, Model 33 KSR, standard duty send/receive) which he used both to send and to receive messages. The teletype machines were slaved together electrically in a single teletype channel, in series, in a broadcast conference network accommodating up to four machines. When any subject typed a message on his terminal, it was simultaneously received, character-by-character as it was being typed, on the other three terminals in the net. In sessions with less than four conferees, the unattended machines were turned off.

The teletype communication system included the following special features:

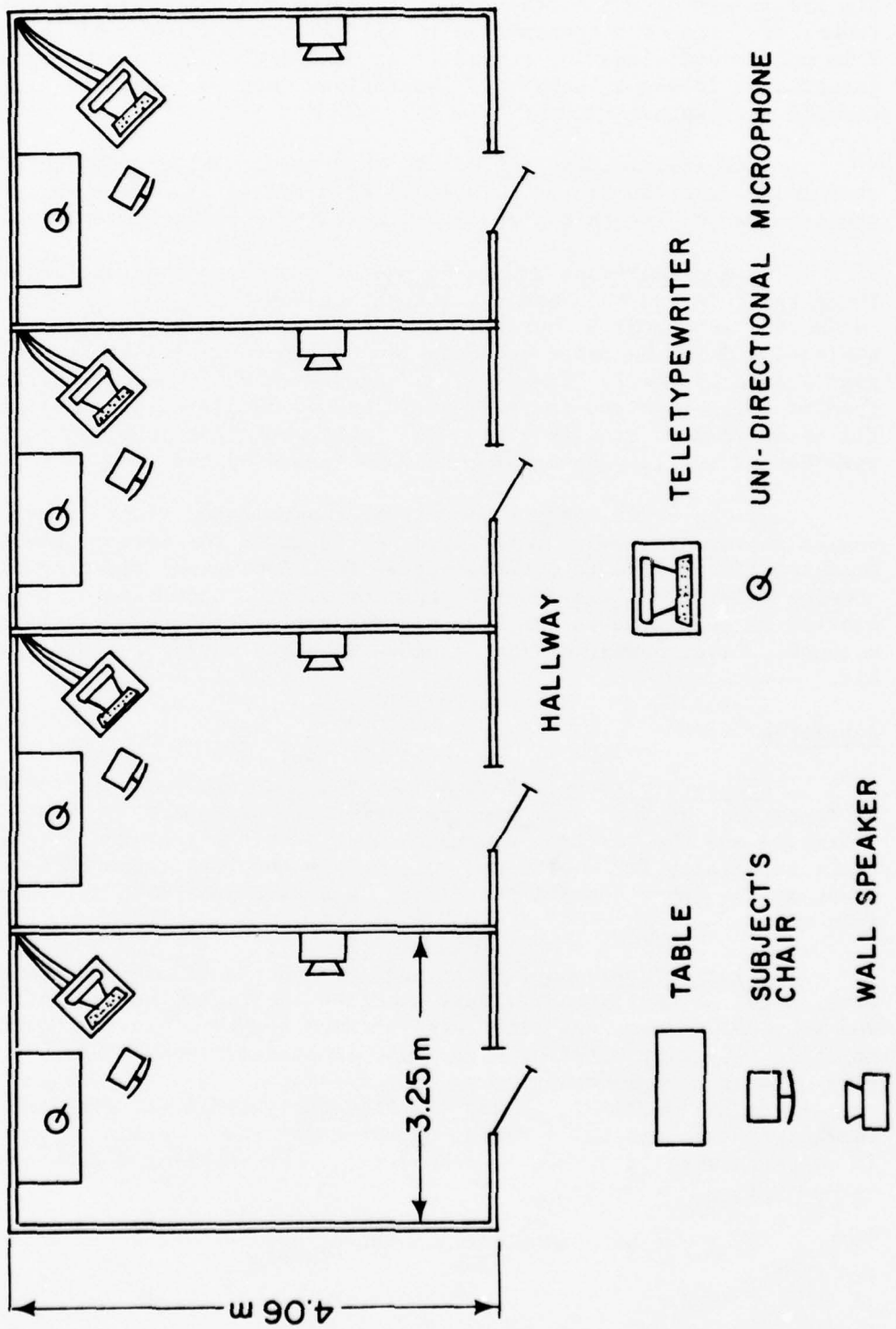

Figure 1. The four interconnecting laboratory rooms used for the conferences conducted in the televoice and teletype modes.

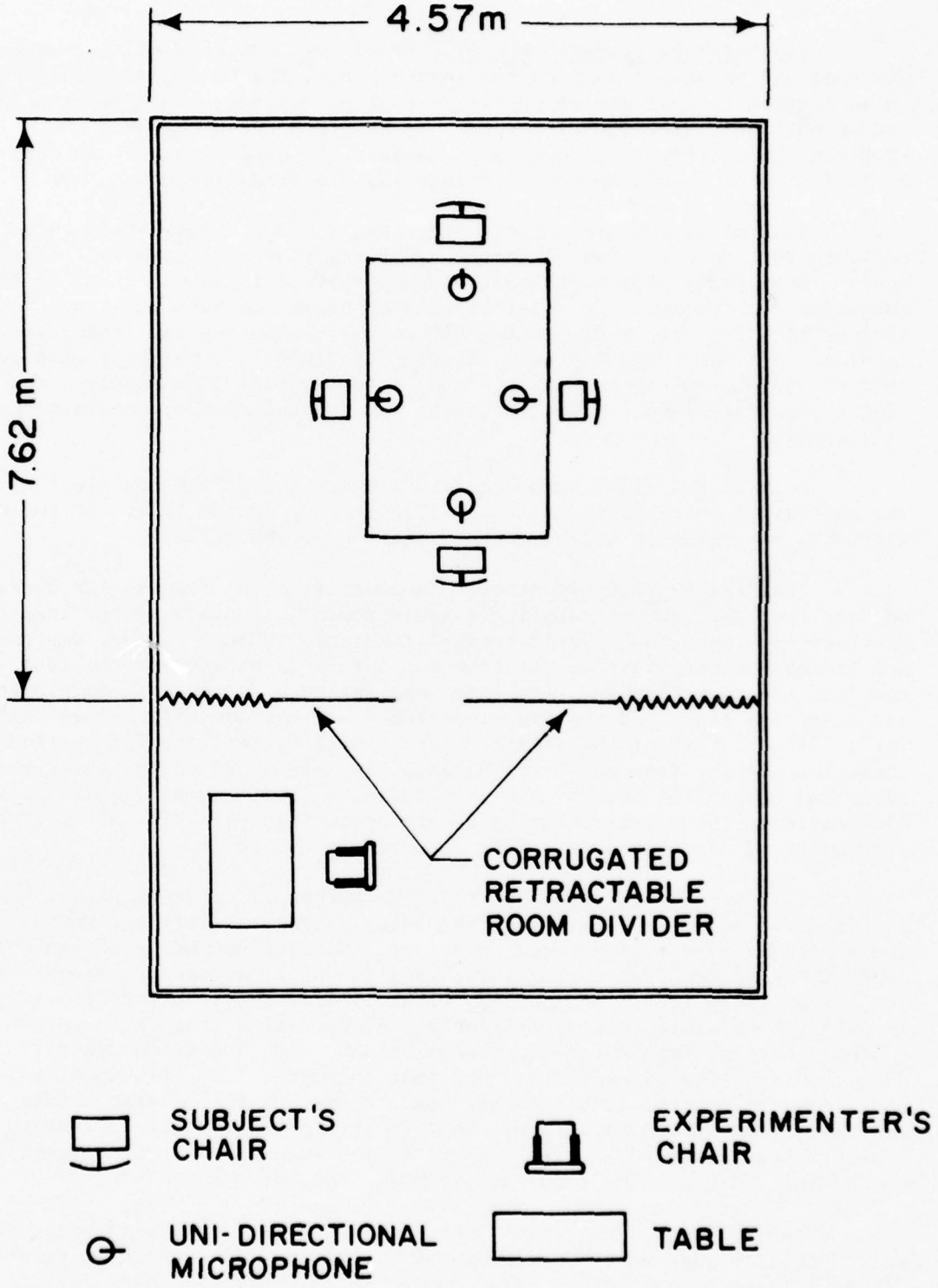

Figure 2. The conference room used for the face-to-face conferences.

(1) Teletype circuit control. Since only one terminal served both the send and receive functions for each subject, the teletype channel had to be limited to half-duplex operation so that messages could be transmitted in only one direction at a time. If this had not been done, any simultaneous attempts by two or more subjects to enter messages at the keyboards would have resulted in unintelligible transmissions.

Control of the circuit was exercised through a pushbutton which replaced the "Here is" button in the upper righthand corner of the keyboard. Depressing this button allowed any subject to take control of the communication channel. He retained control of the channel until another subject took control by depressing the control button on his respective machine. A subject who had been interrupted could, of course, regain control of the channel by pushing his own control button immediately after having been interrupted. Such contests for control of the channel were infrequent.

A small red light automatically illuminated on the console that had control of the teletype circuit. The purpose of the light was to indicate to each subject whether he had control of the circuit.

(2) Message identification. An identification feature was designed into the apparatus by coupling a semi-automatic message sender identification code into the circuit control function. When a subject depressed his circuit control button, the type box carriages on each of the four machines automatically and simultaneously returned to the left margin and spaced up one line, and the type keys typed out the identifier code "A:", "B:", "C:", or "D:" of the sender. This provided immediate information about the machine from which the message had originated and so which conferee had control of the circuit. In addition, the message identification code assisted the experimenter by providing positive identification of the originator of every message on the typewritten protocols.

(3) Carriage returns. On teletype machines, separate pushbutton controls are normally provided on the consoles for the carriage return and the platen advance or line feed functions. Without computerized control of these two functions, typing involves a two step process: (a) depressing the carriage return button and (b) activating the line feed function. In pilot work before this experiment began, operators frequently forgot to depress the line feed after a carriage return, and thus typed directly over the last line of print they had just completed. To circumvent this problem, both control functions were made a part of the message sender identification control function. In this arrangement, then, activation of a single button served to take control of the channel, return the carriage to the left margin, line feed, and identify the message sender.

As a consequence of this feature, each new line of type began with the identifier code of the sender whether a new message was being generated, or a long one was merely being continued for more than one line.

Televoice equipment. The televoice equipment consisted of desk mounted, uni-directional microphones (Sony, Model ECM - 200S) and wall mounted loudspeakers (Lafayette, Model F - 45494) (Figure 1).

Face-to-face equipment. A uni-directional microphone (Sony, Model ECM - 200S) was set on a movable desk stand on the table in front of each of the conference participants. The microphones were used only for recording conversations. Each was fed into a single channel of a 4-channel audio tape recorder operated by the experimenter/observer at the rear of the conference room.

Miscellaneous supplies. All subjects in each session were given several sets of typewritten instructions relating to the particular problem to be solved. A 3"X 5" card listing the letter designation and names of all conferees was in front of each subject during all sessions. Each subject was also provided with paper and pencils for making notes.

Data collection equipment. A sixty-minute timer (Standard Electric Time Corporation, Model S-60-ER) was used to record the length of each experimental session.

The voice communications in both the televoice and the face-to-face modes were recorded by the experimenter on a 4-channel audio tape deck recorder (Sony, Model TC-277-4) tied in series to the microphone systems used by the subjects.

Problem Solving Tasks

The three problem solving tasks were designed to be of topical interest to the students who would serve as subjects. They required the subjects to reach agreement on (a) the priorities to be assigned to certain national issues facing the country today, (b) the order in which a number of University administrative measures concerning academic resources and budget should be implemented, and (c) the priorities for allocating financial support to student activities on the campus.

The tasks were structured in such a way that the basic nature of a task did not change when it was used with two, three or four conferees. In addition, the three problems were all designed to have the same basic cognitive structure and so could be used to test for learning effects on successive days of testing.

Finally, the problems were cooperative in the sense that subjects on a team pooled their collective opinions to work out "solutions." Although cooperative in that sense, the material discussed in each problem elicited a considerable amount of persuasive and argumentative discourse.

National issues problem. The national issues ranking problem, developed by Weeks and Chapanis (1976), consisted of a list of ten national

issues selected from those most frequently cited by students responding to the question: "What are the ten most important issues facing this country?" The issues were variously of an economic, environmental, political, or social nature, but all were judged to be of national concern. They are listed below in the order in which they appeared on the piece of paper given to each subject:

- Provision of equal opportunity in education (4.16)
- Achievement of a stable peace in the Middle East (6.38)
- Control of inflation (9.14)
- Finding a truly effective treatment for drug addiction (1.55)
- Development of alternative energy resources (8.03)
- Allocation of highway funds to mass transit (2.85)
- Restoration of confidence in the political system (4.83)
- Reform of the judicial and penal system (4.89)
- Achievement of zero population growth (3.26)
- Increased consumer protection through legislation (2.65)

Numbers in parentheses are the normalized scaled rank values of the issues (see "Accuracy" or "goodness" of solutions, Page 34).

The problem was administered in two parts. In the first part, the pretest, each subject was asked to rank the issues individually in the order that he would direct attention to them if he could "reorder the national priorities." He was told that his ordering would not be disclosed to the other subject(s) by the experimenter and would not be used in the subsequent conference session part of the task.

In the second part, the group of subjects was told that the experimenter had previously had the same list of ten issues ranked by a large number of undergraduates. The group's task was to work together to rank the issues not as they would privately, but rather as they thought the average undergraduate had ranked the issues. The group was also told that each group member could earn a bonus of up to $3.00 in addition to their hourly pay, the amount of the bonus to be proportional to the correlation between their jointly agreed upon ranking and the ranking found in the student survey. In actual fact, these correlations were not used for this purpose; all subjects were paid approximately the same bonus.

University budget problem. The discussion material for this task consisted of a set of ten administrative, academic and economic changes

that might help to bring the University's budget into balance. The order listed below is that given the students:

- o Delay construction of new buildings and renovation of old ones (8.27)
- o Cut the plant operating expenses (heating, air conditioning, grounds upkeep, etc.) (8.88)
- o Cut the M.S.E. Library operating budget (2.56)
- o Freeze pay hikes for the faculty (4.37)
- o Freeze the hiring of new instructor personnel (5.21)
- o Cut the size of the administrative staff and services (7.51)
- o Raise the student tuition and fees (1.87)
- o Decrease financial aid to students (0.73)
- o Institute a tri-semester system at the University (3.41)
- o Eliminate the Intersession (4.95)

Numbers in parentheses are the normalized scaled rank values of the listed items (see "Accuracy" or "goodness" of solutions, Page 34).

Each subject was asked to imagine that his fellow student(s) had selected him to represent them on an ad hoc committee to make recommendations to the University Administration about these financial matters. In the pre-test he was asked to rank the measures in the order that he would recommend them to the Administration. Again he was told that his ordering would not be disclosed to the other subject(s) and that it would not be used in the group conference part of the task. The procedure for the conference part of this problem was identical to that described above for the national issues problem.

Student activities budget problem. The discussion material for this task consisted of a list of ten organized university student activities for which funding allocation priorities had to be determined. The activities are listed below in the order in which they were given to the students:

- o MaryPRIG (consumer oriented Maryland Public Research Interest Group) (3.17)
- o Band (student concert and marching band) (2.56)

- o Course Guide (publication of opinions on courses offered and on the professors who teach them) (5.76)
- o Hullabaloo (the University's yearbook produced by students) (2.33)
- o News-Letter (campus newspaper published by and for students) (8.73)
- o MSE Symposium (student run event with nationally known speakers) (7.39)
- o Student Council (student representative governmental body) (10.00)
- o Undergraduate Science Bulletin (publication medium for student research) (1.60)
- o Woman's Center (forum to discuss topics of interest to female students) (1.69)
- o Barnstormers (student drama and theater group on campus) (4.48)

Numbers in parentheses are the normalized scaled rank values of the activities (see "Accuracy" or "goodness" of solutions, Page 34). The explanatory remarks in parentheses did not appear on the materials given to the students. They are given here only to help the reader understand what the student activities were about.

In the pre-test part of this problem each subject was asked to imagine that he had been appointed to a committee responsible for deciding how funds should be apportioned among these ten student activities for next year's budget. He had to rank the activities in the order that he would assign funds to them. Otherwise, the procedure followed that of the two preceding problems.

Experimental Design

The experimental design (Table 1) was a mixed design (Myers, 1972, pp. 191-225) with two between-groups variables (group size and communication modes) and two within-groups variables (days and problems). The order of presentation of the problems was balanced across days in a Latin square format that was replicated across communication modes and group sizes.

Nine two-man, nine three-man and nine four-man groups, or a total of 27 groups and 81 subjects, were tested. Three groups of each size were assigned to each mode of communication, and all groups solved each of the three problems.

Table 1

Experimental Design

Group Size	Communication Modes	Groups	Day 1	Day 2	Day 3
2-Man Groups	TTY	G 1	P 1	P 3	P 2
		G 2	P 3	P 2	P 1
		G 3	P 2	P 1	P 3
	TELEV	G 4	"	"	"
		G 5			
		G 6			
	FTF	G 7	"	"	"
		G 8			
		G 9			
3-Man Groups	TTY	G 10	"	"	"
		G 11			
		G 12			
	TELEV	G 13	"	"	"
		G 14			
		G 15			
	FTF	G 16	"	"	"
		G 17			
		G 18			
4-Man Groups	TTY	G 19	"	"	"
		G 20			
		G 21			
	TELEV	G 22	"	"	"
		G 23			
		G 24			
	FTF	G 25	"	"	"
		G 26			
		G 27			

P 1 = National Issues Problem
P 2 = University Budget Problem
P 3 = Student Activities-Budget Problem

TTY = Teletype Mode
TELEV = Televoice Mode
FTF = Face-to-face Mode

Table 2 shows the form of the analysis of variance used in treating the dependent measures.

Procedure

The subjects were recruited from students at The Johns Hopkins University via posters and sign-up sheets advertising an opportunity to participate in an interesting communication experiment. The posters emphasized the monetary compensation that would be paid for participation.

Each subject was scheduled with one or more others to form groups of 2, 3, or 4 subjects. Subjects who admitted either to being close friends or to occasionally socializing together were assigned to different groups. No attempt was made to match subjects on typing skill level for the teletype mode or on verbal ability for the televoice and face-to-face modes. The assignment of groups to experimental conditions was randomized. Subjects remained in the same group throughout three sessions. Each group participated in one experimental session per day, for three days, and used only one communication mode throughout all sessions.

When the subjects arrived for the first session they were introduced to one another and remained together while the experimenter read them a prepared set of instructions. The instructions (a) stated that the purpose of the experiment was to study communication, (b) explained the general nature of the tasks, and (c) described how the subjects would be communicating. The experimenter also demonstrated all the equipment that the subjects would be using. The subjects were told that they could use any problem-solving strategy they felt was appropriate and that they could do or say anything that would help their group reach a solution.

The subjects were also told that audio tape recordings, teletype printouts, observer notes, and other records would be collected during the sessions. They were told that the records would be kept confidential for use in data analysis and for research purposes only. Written permission to collect these records was obtained from the subjects.

Each subject was then conducted to his workplace in his assigned room or was seated around the conference table. Problem-related materials and specialized instructions for each problem were distributed. The subjects were then allowed to practice using the communication apparatus. When the experimenter was satisfied that the subjects were familiar with the equipment, procedures and task, he gave the signal to begin.

At the completion of the third experimental session the subjects completed a questionnaire that sampled their opinions about the communication mode they had used and on the group's ability to solve problems by communicating that way.

Table 2

Form of the Analysis of Variance for

the Experimental Design in Table 1

Source of Variation	Degrees of Freedom
I. Between Groups (G)	26
Group Size (GS)	2
Modes (M)	2
GS X M	4
T / GS X M	18
II. Within Groups	54
Days (D)	2
Problems (P)	2
GS X D	4
GS X P	4
M X D	4
M X P	4
GS X M X D	8
GS X M X P	8
Pooled Latin Square Error (L.S.E.)	18
Overall L.S.E.	2
M X Ind. L.S.E.	4
GS X Ind. L.S.E.	4
M X GS X Ind. L.S.E.	8
III. Total	80

Data Collection and Analysis

Four kinds of data were collected: (a) time required to solve the problem, (b) verbal measures of communication, (c) two sets of rankings for the items in each problem: the personal rankings of each subject and the group's consensus solution for the problem, and (d) responses to the questionnaire completed by the subjects at the end of the third session.

Time to solution. The time required to solve a problem was the elapsed time from the moment the experimenter told the conference group to begin until one of the conferees told the experimenter that the group had reached a consensus solution. Since the total time to solution is a measure of group performance, it is identical for all of the members of the group. Therefore, analysis at the level of subjects within groups (Table 2) was not appropriate.

Communication protocols. In the teletype mode each group of subjects generated hard-copy printouts of their verbal exchanges. In these printouts, messages were identified by the subject's letter code: "A:", "B:", "C:", or "D:".

In the two oral modes, messages spoken by each team member were recorded on separate channels of an audio tape to aid in the identification of each speaker. The tape recordings were transcribed to typewritten protocols by four secretary-transcribers. The experimenter verified all transcriptions against the tapes for accuracy, after which a corrected copy was typed for use in extracting the data.

In producing the typed transcripts of the oral communications, the aim was to obtain highly accurate reproductions of the many rapid and complex verbal exchanges that took place. The rules of transcription were those formulated by Chapanis et al. (1972), Chapanis et al. (1977) and Weeks & Chapanis (1976). Essentially they combine the use of conventional English orthography with the preservation of the subjects' natural style of communication. For example, elisions common to English speech, e.g., "gonna," were transcribed as spoken rather than as their constituent words. Punctuation was added to the transcripts on the basis of context, word order and intonation. Because judgments about punctuation are so difficult and so subjective, no measures were made of any linguistic units that rely on punctuation, e.g., the number of sentences.

Number of messages. A message began when a subject began to talk or to type, and ended either when he had finished and relinquished control of the communication channel to his partner(s), or when he stopped talking or typing because he was interrupted by his partner(s). By this definition, therefore, a message may be a word, a group of words, a complete sentence or question, or several sentences or questions. Messages counted in this way measured both verbal productivity and the frequency with which subjects exchanged control of the communication channel.

Since two or more conferees could talk simultaneously in the voice modes, messages could overlap. Lines 2, 3, and 4, 7 and 8, and 11 and 12 in Table 3 illustrate such overlapping. Frequently, the subject who had been speaking first would stop almost immediately upon being interrupted, as shown in lines 19 and 20. Occasionally, however, a subject would continue talking and his partner(s) would superimpose two or more discrete utterances on the one long message of the first subject. Such overlapping messages occurred with each of the three sizes of groups. Even in the two-man conferences the group members could and did produce different numbers of messages.

The numbers of messages exchanged by all conferees in a group were pooled in each problem solving session to provide measures of group performance. The total number of messages used by a group divided by the number of conferees in the group yielded a measure of the number of messages used by the average conferee.

Number of words. Although counting words is not inherently difficult, establishing the rules of what to count is. In a "hard copy" communication mode, e.g., teletype, where the communicators print out their own messages, a general rule for making word counts could be as simple as defining a word as any string of letters and/or digits surrounded by spaces. Such a definition, used by Kelly (1974), is easily adaptable to making word counts by computer. However, in making counts from transcripts of spoken communications, such a decision logic is neither very realistic nor practicable. Mispronunciations, elisions and contractions, partially completed words, and colloquial interjections and vocal gestures all require a more elaborate set of rules.

On the assumption that most verbal utterances and typewritten sequences of symbols convey some information, my definition of what constituted a word was extremely liberal. The rules used in making the word counts are based on those established in earlier communication experiments in the Chapanis laboratory (Chapanis & Overbey, 1974; Chapanis et al., 1977; Weeks & Chapanis, 1976). Some of the principal rules were:

1. Mispronounced words in the voice modes and misspelled words in the teletypewriter modes were counted as words.

2. Partial and incomplete words were counted as words. For example, "'em," "'cause," and "wh'" were all counted as single words.

3. Colloquialisms, slang, and apparent neologisms were counted as words. For example, "yup," "nope," and "daggone," were all counted as single words.

4. Contractions and elisions, both standard and nonstandard, were counted as words. For example, "I'll," "can't," "don't," "gotcha," "kinda," and "Y'know," were counted as single words.

Table 3

Some of the Exchanges Among Four Conferees Who Solved the National Issues Problem in the Face-to-Face Mode

D: Whether they think that

{D; can be solved
B: Well,
A: Yeah.

D; by putting more money into it or not, I don't know but,

A: that seems to be the idea though, the notion

{A; that I get is that money's gonna solve it.
B: But that, there's still this, this goes back to

B; umm, the mass transit goes back to the energy crisis too. You know,

{B; as far as
C: Um-hmm

B; the gasoline shortage.

{D: Um-hmm
C: Yeah

C; plus I think it would be a pretty big ah, shift to get the general population away from private cars onto mass transit.

{C; And/
A: I mean they,

A; they can see the need, the, the problem there

C: Yeah, right now there's a pressing need. Oh, not really pressing, but I think there's a stronger need for better highways...

Note. A solidus (/) indicates the speaker was interrupted at that point. A brace ({) in front of the speaker identifier codes encompasses those portions of speech that occurred simultaneously. A semi-colon after the speaker designation (e.g., A;) indicates continuation of a message.

5. In the teletypewriter mode combined numerals, e.g., "21," were counted as single words. In the voice modes, however, the same numbers may have been spoken as "twenty-one," which was counted as one word, or as "two one," which was counted as two words. A year, e.g., 1899, was counted as one word when spoken as "eighteen-ninety-nine."

6. Interjections and vocal gestures, such as "hmm," "whew," "ah," and "uh" were counted as words on the grounds that they could, and usually did, convey some information.

7. Laughter, recognizable snickers, and guffaws were each counted as one word no matter what the duration of the utterance. They were counted as words on the grounds that they could, and usually did, convey some information.

8. Hyphenated words, whether correctly hyphenated or not, were counted as single words. For example, "re-distribute," and "ear-mark" were counted as single words.

9. Abbreviations and acronyms were counted as words. For example, "ZPG," "Z.P.G.," or "Z-P-G" were counted as single words whether spoken or typed. However, "Zero Population Growth" was counted as three words.

10. Special symbols were counted as single words. For example, "@10¢" was counted as three words, @, 10, and ¢, and "#6-9" as four, #, 6, -, and 9. The dash " - " in this latter case stands for "through." Question marks were occasionally interpreted as single words in the teletypewriter mode. This usually occurred when a subject typed only a question mark, "?," as his entire message.

11. Words run together or erroneously spaced in the teletypewriter mode were counted as their apparent constitutent words. For example, "tuitionhike" and "en ergyer isis" were each counted as two words.

The number of words used by each subject was counted both by the experimenter and a paid assistant. Any disagreements between the two counts were resolved to yield the final count used in subsequent analyses. The counts for all conferees in a group were then pooled to provide a measure of group performance. The total number of words used by a group divided by the number of conferees in the group yielded a measure of the number of words used by the average conferee.

Message lengths. Mean message length, the average number of words per message, was derived by dividing the number of messages generated by a group into the total number of words it used.

Communication rates. Two measures of communication rate were computed: (a) the number of messages per minute (Msg/Min), derived by dividing the total number of messages used by the group by the total time in minutes required to reach a solution, and (b) the number of words per minute (W/Min), calculated by dividing the total number of words used by the group by the total time in minutes.

Disparities among group members in performance. Coefficients of variation (Peters and VanVoorhis, 1940, pp. 78-79) were computed for the numbers of messages and the numbers of words used by the subjects within each group. This coefficient allows one to compare the relative variabilities of several sets of data when the data have been corrected for differences among their means. The formula is:

$$V = \frac{100\,\sigma}{M},$$

where V is the coefficient of variation, σ is the standard deviation of the distribution, and M is the mean of the distribution.

"Accuracy" or "goodness" of solutions. Two sets of rankings for each problem were collected from the subjects in each session: (a) a ranking of each subject's private views on the issues before the conference, and (b) the group's consensus ranking representing how the group members thought the average undergraduate ranked the same 10 items. The initial rankings made by all 81 subjects were pooled for each problem and the 10 items in each problem were scaled by the normalized rank method (Guilford, 1954). The final normalized scale ranks for the items in each of the problems are given on pages 24, 25, and 26. The highest scale ranks indicate the issues or items to which the subjects gave highest priorities. A product moment correlation coefficient was then computed between the pooled scale values and each group's consensus ranking. The eighty-one resultant r's were transformed to Fisher z's (McNemar, 1969, p. 157) and the latter were analyzed by the analysis of variance in Table 2. If the pooled initial rankings of all 81 subjects are considered a criterion, or measure of the student views in general, the correlation between a group's consensus rankings and the criterion rankings constitute a kind of quality measure of the "goodness" or "accuracy" of a group's solution.

Questionnaire data. The questionnaire was designed to get opinions about (a) the communication mode the subjects had used, (b) the size of group in which they had worked, and (c) how the group functioned on successive days. The questions were also designed to elicit information about any critical incidents that might have occurred during the several conferences. Because of the open-ended nature of the questions, and the qualitative nature of the responses, the questionnaire data do not lend themselves to complex statistical treatment. Responses were simply classified in a few broad categories and frequency counts were made of the numbers of responses in those categories.

Results and Discussion

The results of the analyses of variance on all the quantifiable dependent measures are shown in Table 4. Two-thirds of the significant effects are for the three main variables of Group Size, Communication Mode, and successive Days of test. Over half of all the significant effects are attributable to Group Size and Communication Mode. Note also the small number of significant interactions: Out of 77 potentially significant interactions, only six were significant.

The most important implication of these findings is that Group Size and Communication Mode appear to be highly important variables in determining performance in teleconferences but that these two variables are almost entirely independent of one another. Moreover, the effects of Group Size and Communication Mode are extremely robust, that is, their effects appear to be stable for all three Problems and over all three Days of test.

The four significant effects obtained on successive Days of the test show that some changes in group performance occur in the communication process and that these changes can be demonstrated as early as the third day. Once again, the very few significant interactions involving Days (3 out of 33) suggests that whatever changes occur over time are largely independent of the other main variables.

Time to Solution

Table 4 shows that statistically significant differences in time to solution were found only among Communication Modes (Figure 3). On the average, groups conferring by teletype took over twice as long to arrive at a consensus as did those who conferred by televoice, and over one and one-half times as long as those who met face-to-face. One important feature that distinguishes communication by teletype from the other two modes is that the former does not have a voice channel. Based on earlier work from this laboratory, especially that of Ochsman and Chapanis (1974), it is the presence or absence of a voice channel that is the critical feature in determining time to solution. The orthogonal comparison between groups that worked in the teletype mode and those that conferred in the other two modes (teletype vs. face-to-face + televoice), was highly significant ($0.001 < p < 0.005$). Since this was the only significant orthogonal comparison and since this one comparison accounted for 88.5% of the variance among modes, it is evident that the difference between communicating with a voice channel versus communicating without the voice channel is a very strong one. This finding has already been well documented (Chapanis et al., 1972; Chapanis & Overbey, 1974; Ochsman & Chapanis, 1974; Parrish, 1973; Weeks & Chapanis, 1976) in studies with two-man teams. The findings here, and especially the lack of a significant interaction between Group Size and Modes, show that the effects previously reported for two-man groups hold for 3- and 4-person groups as well.

Table 4

p Values of All Statistically Significant Effects Identified by the Analyses of Variance for the 11 Dependent Variables

Dependent Variables	Between Groups			Within Groups								
	Group Size (GS)	Modes (M)	GS X M	Days (D)	Problems (P)	GS X D	GS X P	M X D	M X P	GS X M X D	GS X M X P
Time to Solution		.005									
Verbal Measures											
Number of Messages per Group	.005	.001									
Number of Words per Group	.025	.001		.050		.025					.005
Mean Message Length	.050			.025	.025			.050			
Messages per Minute	.001	.001	.025		.025						
Words per Minute	.005	.001									
Number of Messages per Person		.001									
Number of Words per Person		.001		.050						.005	.001
Relative Variability among Numbers of Messages	.001	.005		.025							
Relative Variability Among Numbers of Words											
Accuracy of Solution					.005						

Note: The p values are those of the upper limit of the intervals: $p<.001$, $.001<p<.005$, $.005<p<.010$, $.010<p<.025$, $.025<p<.050$.

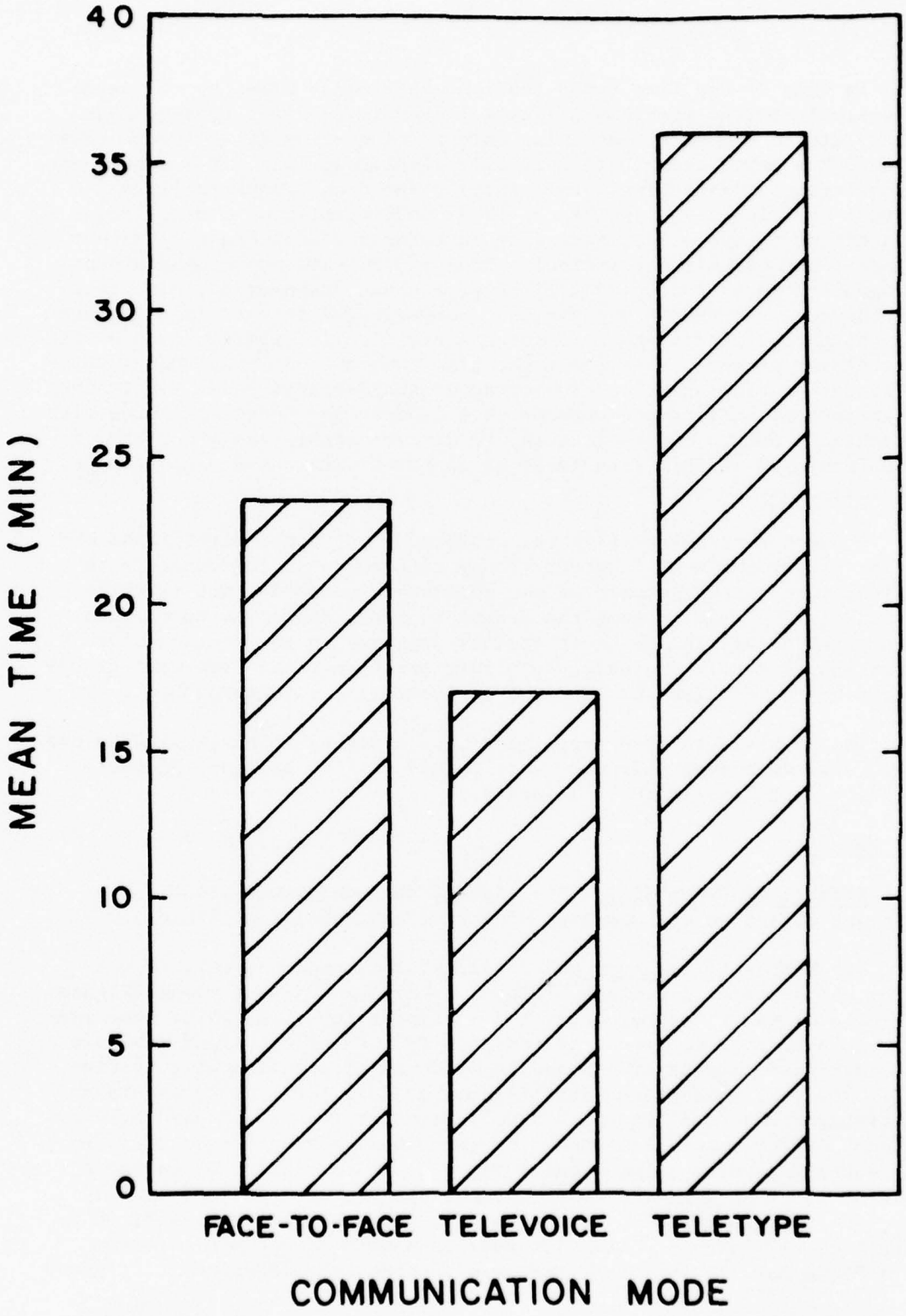

Figure 3. Mean problem solution time as a function of communication mode.

In four of the five communication experiments cited above, teams also generally solved problems a little faster in the face-to-face mode than they did in the mode containing only a voice channel. Although this difference has never been a statistically significant one, it has at least been consistent in direction. For example, Weeks and Chapanis (1976) found that solution times in the telephone mode were about 3 min. longer than in either of two voice modes that included a visual channel (face-to-face and closed circuit television). However, in this experiment groups that communicated by televoice arrived at a consensus over 6.6 min. faster, on the average, than did those that communicated face-to-face (Figure 3). Although the finding here is not a statistically significant one, it is interesting because it is the first time that an audio mode has resulted in faster problem solution times than an audio-visual mode. It is not clear whether the difference between this finding and those of the earlier experiments is due to chance factors, to differences in the structure of the problems used in this experiment as compared with those used earlier, or to still other factors.

Of much more interest is the absence of any other significant effects for solution times. Contrary to my expectations, and contrary to intuition, increasing the size of the conference group did not significantly change the time it took the groups to reach consensus agreements. Nor did working together on three similar problems in three successive sessions (Days) result in faster or slower solution times even when groups were allowed to converse via the same communication mode throughout.

The problems in this experiment were designed to be similar to one another. The data show that they were indeed similar at least in the amount of time taken for their solution.

Verbal Measures

Effects of Group Size. The size of the conference group had a significant effect on six measures of verbal communication (Table 4).

(1) Number of messages and words. Verbal productivity, as measured by the numbers of messages (Figure 4 and Table 5) and words (Figure 5 and Table 5) increased regularly and in almost identically the same manner as the number of conferees increased. In both cases, trend analysis shows significant linear trends and no evidence of significant curvilinearity. However, when productivity is measured in terms of the average productivity per person (Figure 6 and 7) rather than average productivity per group, differences attributable to group size are no longer significant. There is, to be sure, a small increase in the number of messages per person as group size increases (Figure 6), but the increase is very small compared with that shown in Figure 4, and, as already stated, it is not statistically significant. The average number of words per person (Figure 7) is for all practical purposes constant and independent of group size.

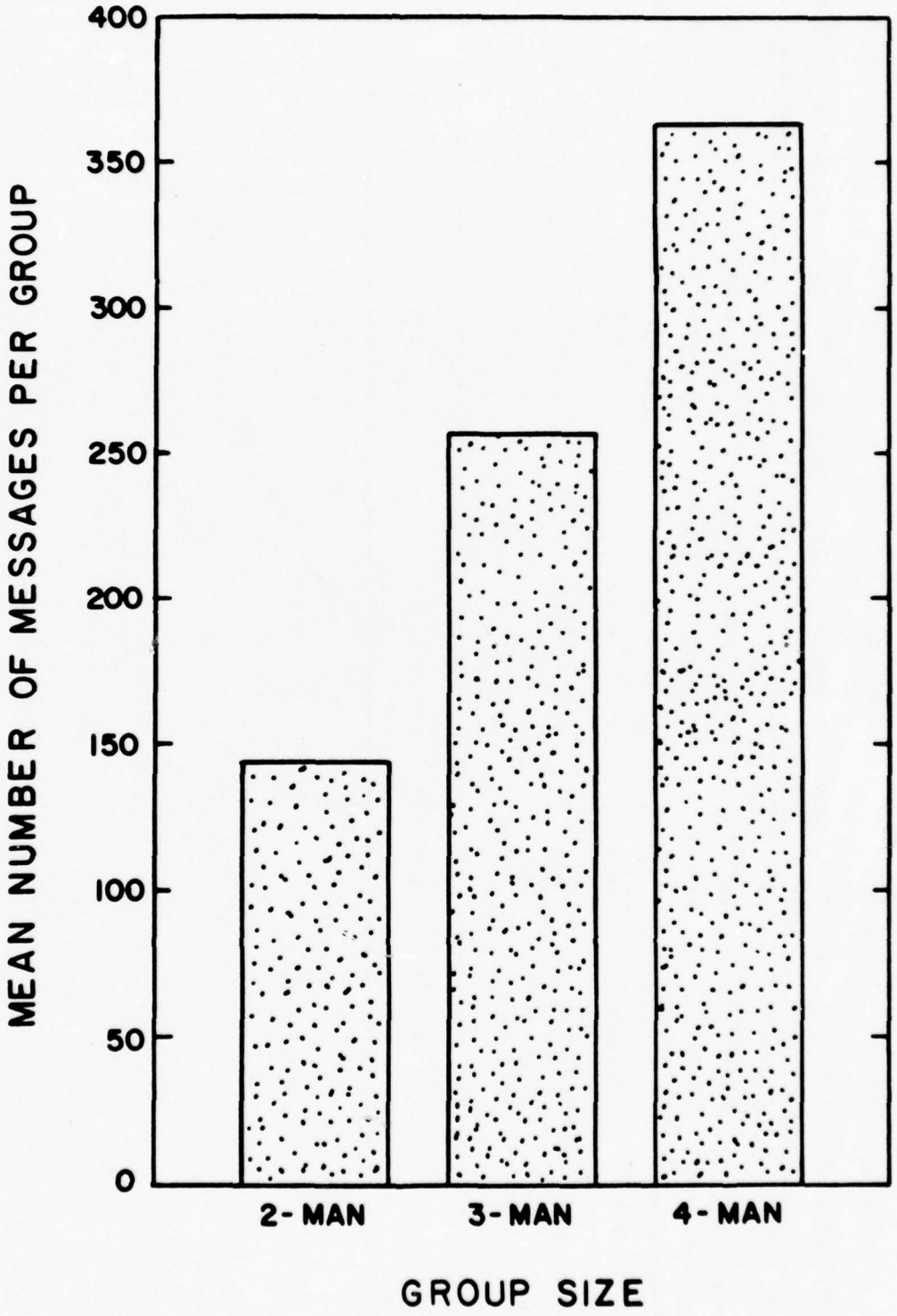

Figure 4. Mean number of messages per group as a function of group size.

Table 5

Mean Values for those Verbal Measures in which there were Statistically Significant Effects Attributable to Group Size

Group Size	Number of Messages	Number of Words	Mean Message Length	Communication Rate: Messages per Minute	Communication Rate: Words per Minute	Mean Relative Variability
2-Man	144.6	1736.4	12.1	8.2	99.2	2.5
3-Man	258.6	2482.2	9.3	12.1	115.1	18.2
4-Man	361.3	3697.3	9.8	14.3	146.4	21.9
Mean	254.8	2638.6	10.4	11.6	120.2	14.2

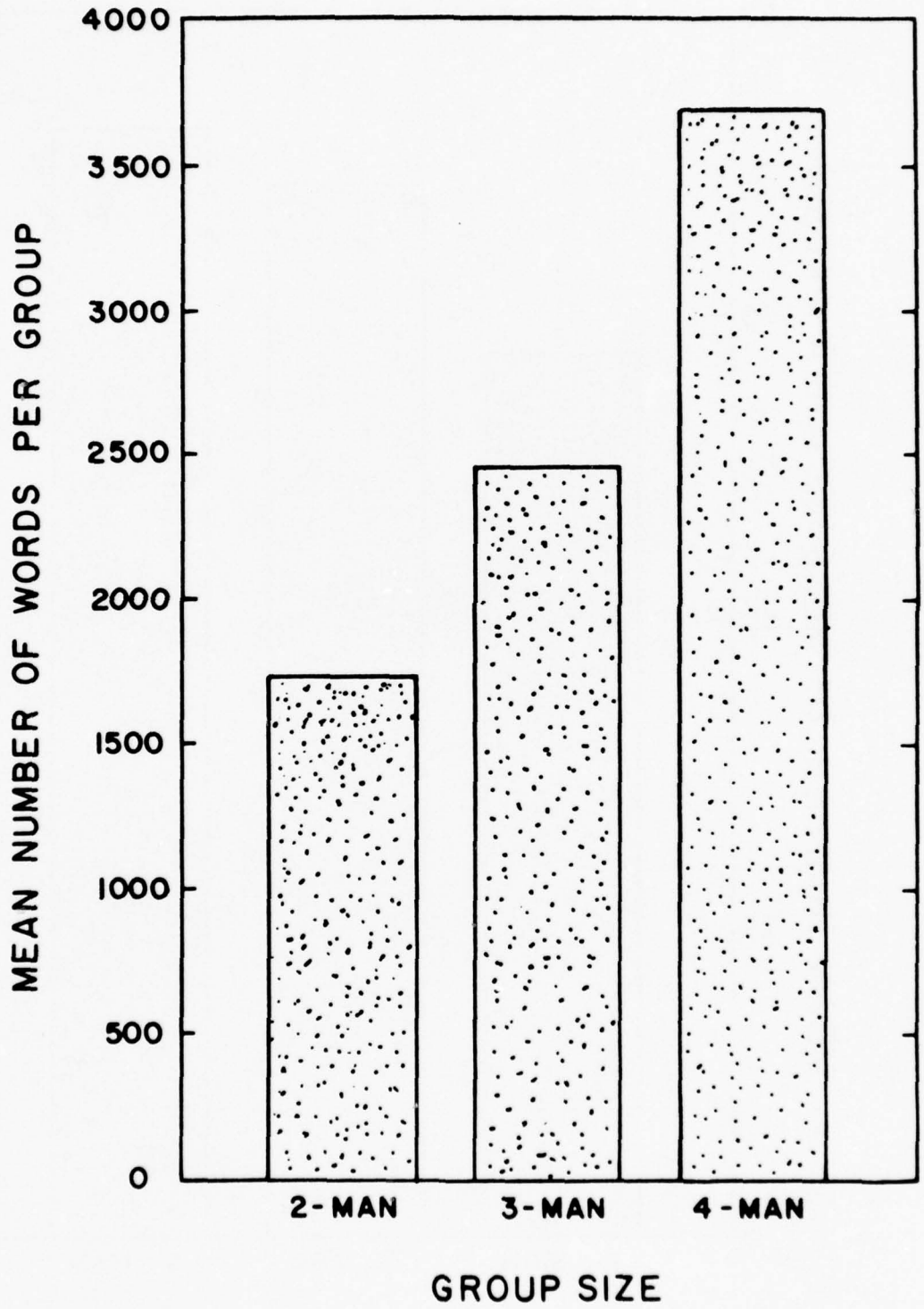

Figure 5. Mean number of words per group as a function of group size.

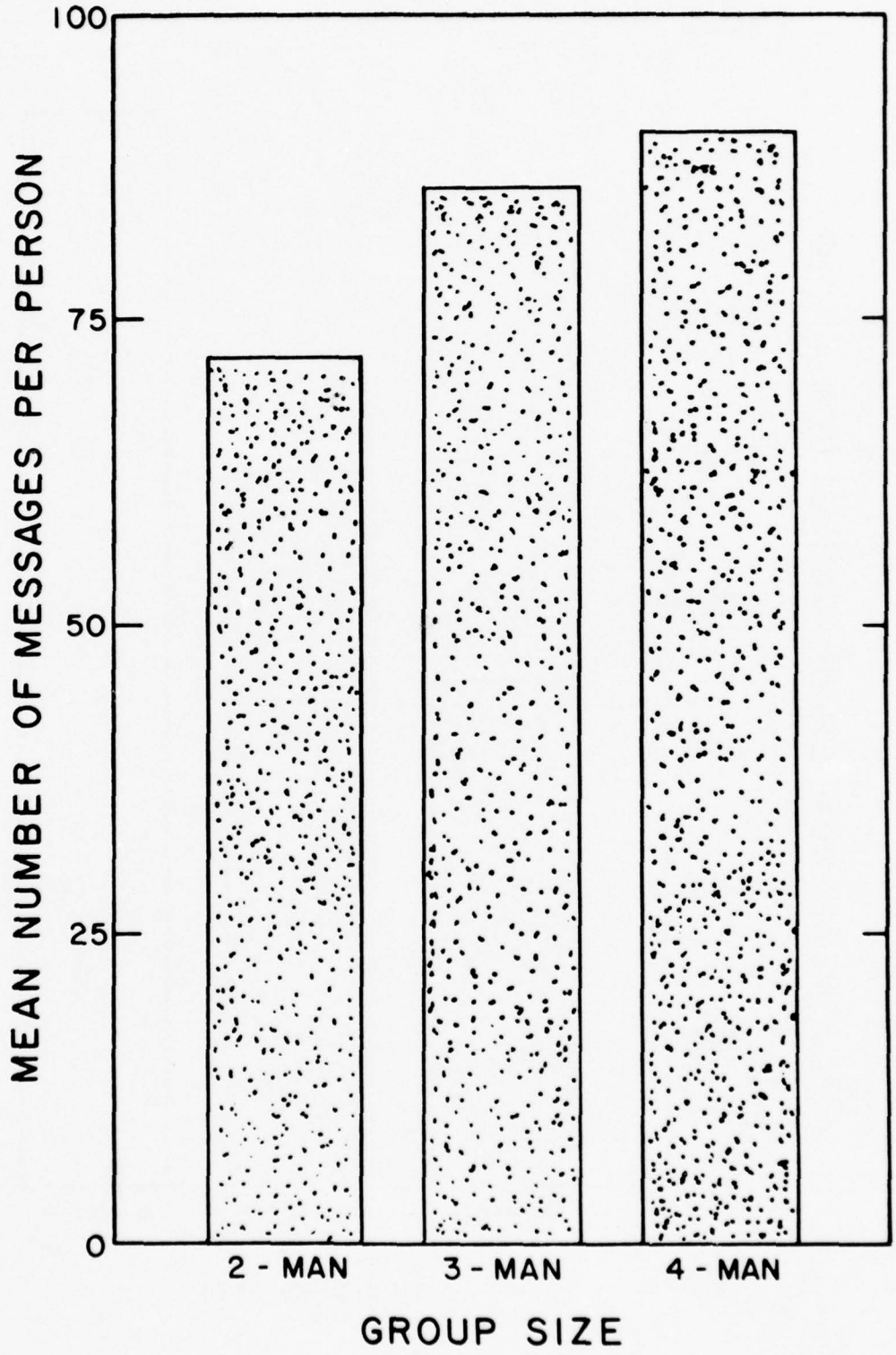

Figure 6. Mean number of messages per person as a function of group size.

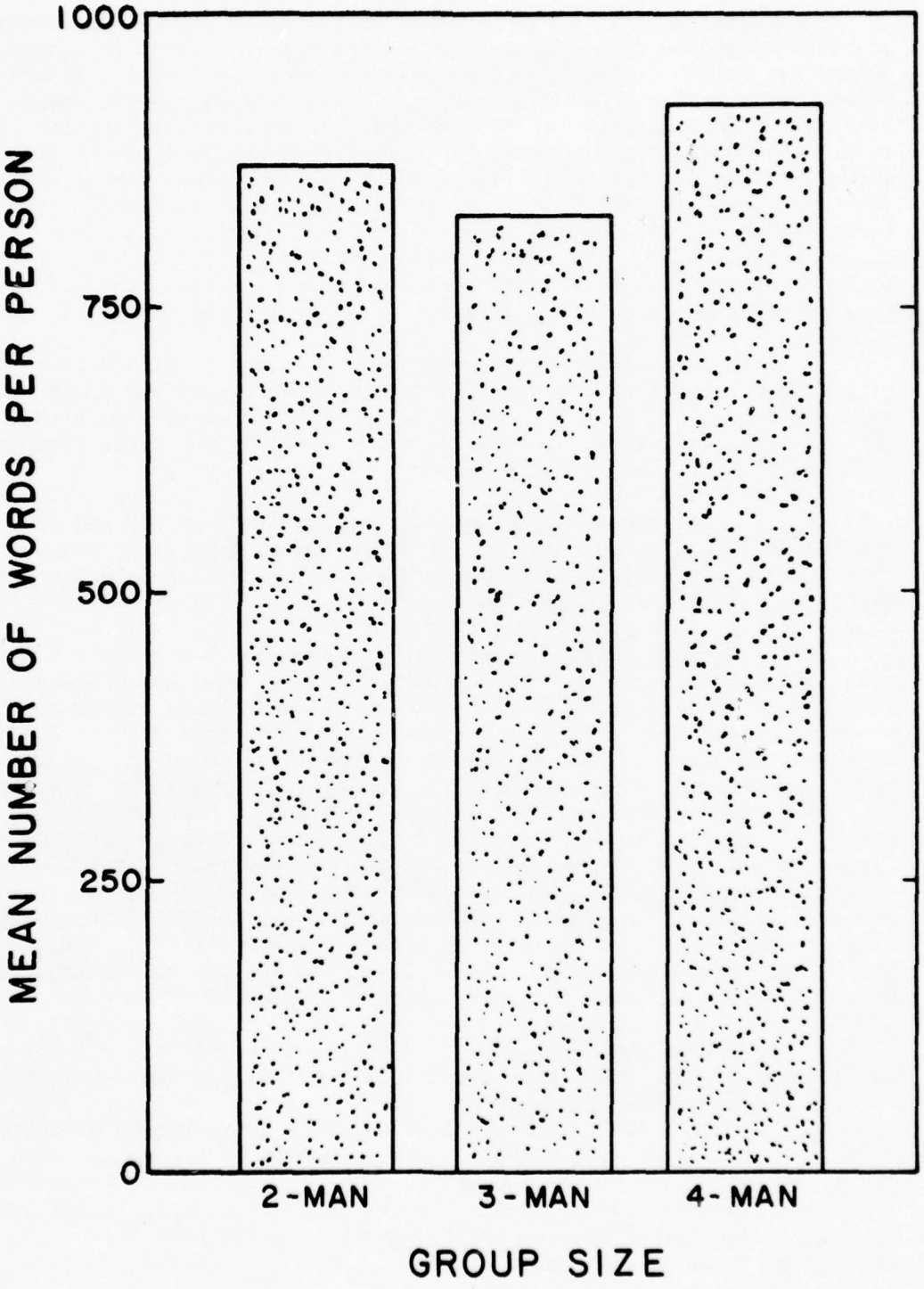

Figure 7. Mean number of words per person as a function of group size.

Taken together, these findings suggest that group verbal output, as measured by the number of messages and words, increased in a regular, linear way as the number of conferees increased from 2 to 4. This increase would appear to be due entirely to the increase in the number of conferees. Each addition of another conferee to the group resulted in a relatively constant increase in the number of messages (between 70 to 90) and words (between 825 and 925). Under those circumstances, verbal output for the group would naturally increase as the group size increases. However, these figures on the average verbal productivity per person should not be taken too literally. The group communicative output is not shared equally among group conferees, that is, some conferees talk more than do others (See the section on Relative variability among messages, Page 50).

It is also important to note that there are no significant interactions of Group Size with Modes or Problems for either the number of messages or number of words. In other words, the differences in verbal output for the three different sizes of group hold for all three communication modes and for all three problems.

Two other interactions involving group size, GS X D and GS X M X P, will be discussed later. Suffice it to say in anticipation, however, these two interactions do not really alter the general conclusions about the strong effects of group size on verbal output.

(2) Message length. Although Figures 4 and 5 and Table 5 show a nearly linear increase in both the numbers of messages and words as a function of group size, the data are clearly not exactly linear and neither slope is exactly 1.00 (This is especially apparent from Figures 6 and 7). As a result, dividing the one measure by the other to get a measure of words per message, or message length, reveals some small, but statistically significant differences (Figure 8 and Table 5). Messages in the two-person groups were about 25 percent longer, on the average, than in the larger groups. The difference between the message lengths for the 3- and 4-person groups is small and not statistically significant. Since there are no significant interactions involving Group Size, the findings about message lengths for the three group sizes hold for all three Communication Modes, all three Problems, all three Days, and for all combinations of Modes, Problems and Days tested in this study.

One likely explanation for the longer messages in the 2-person conferences is that there were fewer interruptions and fewer simultaneous conversations in those conferences. There were 624, 1444, and 2839 occurrences of simultaneous speech for the 2- , 3- , and 4-person groups respectively in the two voice modes. One or another conferee was much more likely to interrupt, or to talk at the same time as some other conferee, in the 3- and 4-person groups than in the 2-person groups. Those interruptions and simultaneous conversations may have been responsible for the shorter messages in the larger groups.

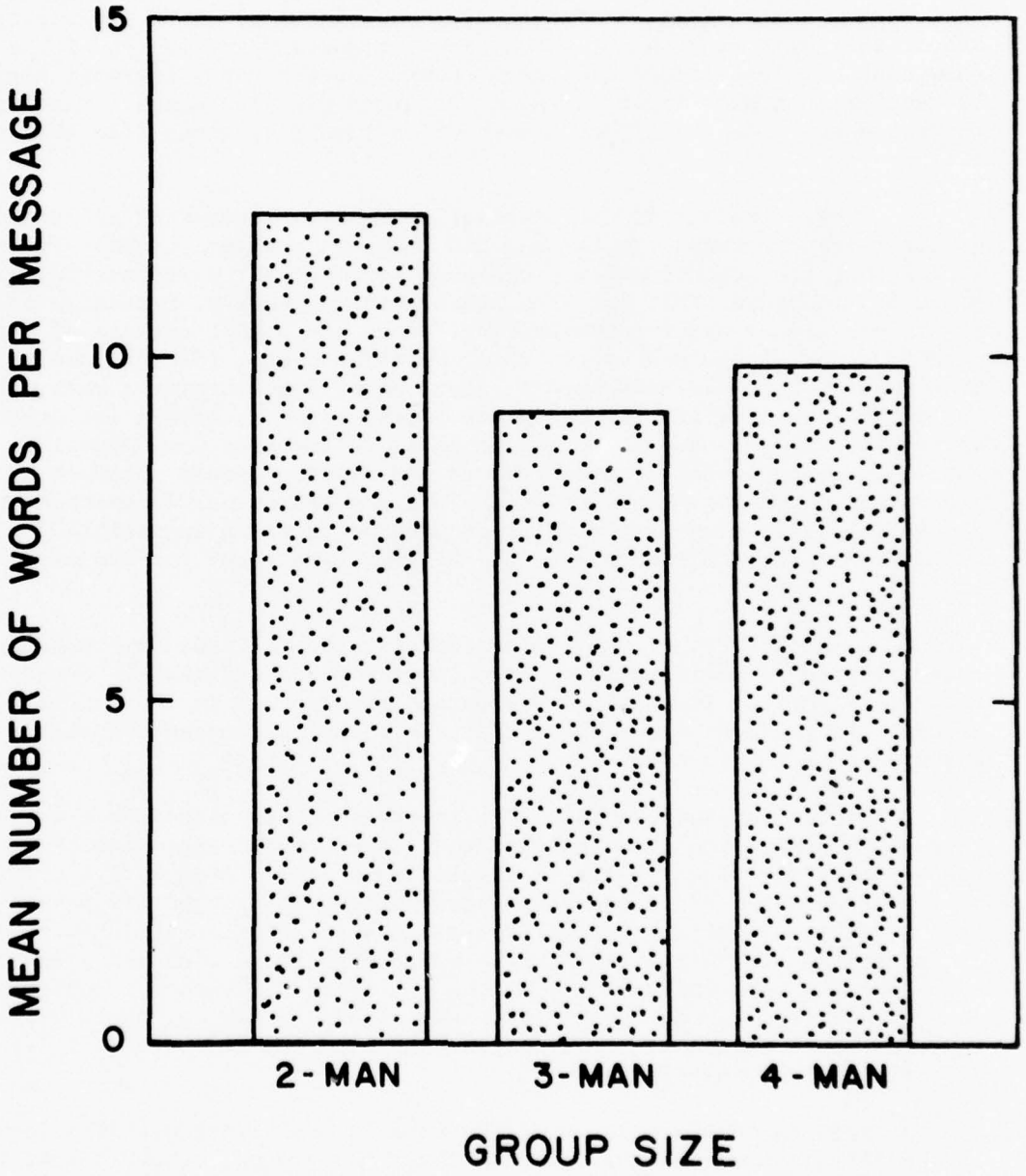

Figure 8. Mean message length (words/message) as a function of group size.

(3) Communication rates. As noted above, times to solution did not differ for the 2- , 3- , and 4-person groups, but numbers of messages and numbers of words did. That being the case, it follows that communication rates, measured either in messages per minute or words per minute, should vary as a function of group size. Figures 9 and 10, and Table 5, show that this was indeed the case. Communication rates increase regularly, and in an almost linear fashion, as group size increases. Moreover, there was only one significant interaction involving group size (Figure 11).

These findings do not necessarily mean that subjects in larger groups talked or typed faster than did those in smaller groups. First, recall that the communication rates used here are not pure measures of communication rate, that is, they are not the numbers of messages, or words, per minute spent communicating. They are rather numbers of messages, or words, divided by the total solution time. In other words, the time measure here includes pauses, gaps, and silent intervals when nothing was being communicated. If there are fewer silent intervals in larger conferences than in smaller ones, it would follow that communication rates, in messages per minute or words per minute, should increase as group size increases. This would explain why the number of messages per minute increases even in the teletype mode where it is impossible for two or more conferees to communicate at the same time (See, for example, Figure 11).

A second part of the explanation for the increase in communication rates relates to the data on message lengths discussed above. Messages tend to be shorter in the 3- and 4-person groups than in the 2-person groups. If messages are shorter and total time is constant, then messages per minute could increase.

The third, and probably most important explanation for the findings on communication rates is that the larger conferences were characterized by many more occurrences of simultaneous speech than were those involving 2 persons. In a two-person conference, one person was perhaps less likely to interrupt his partner since such an interruption would decrease the chance that either person would comprehend what was going on. In 3- and 4-person conferences, on the other hand, whenever a conferee began to speak while some other person was already speaking, there was at least a chance that a third or fourth member of the group would shift his attention to the new speaker.

Such an interpretation of the data is consistent with the interaction illustrated in Figure 11. In the 2-man groups, communication rates are about equal in the face-to-face and televoice modes. For the 3- and 4-man groups, however, communication rates in the face-to-face mode were substantially greater than in the televoice mode. In a 2-person group, simultaneous speaking represents a direct and obvious interference with the only other person in the conversation. In a 3- or 4-person group,

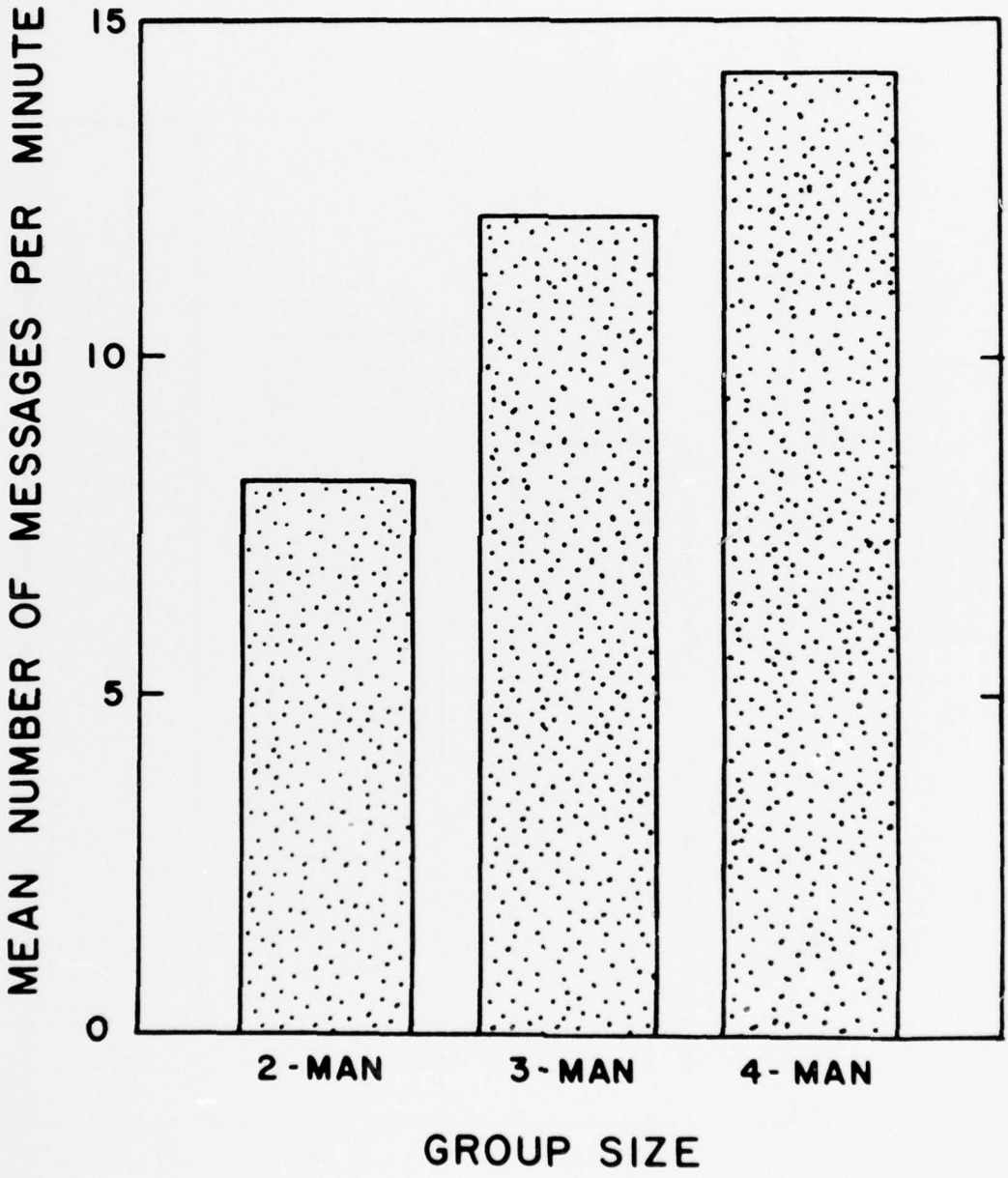

Figure 9. Mean communication rate (messages/minute) for each of the three sizes of group.

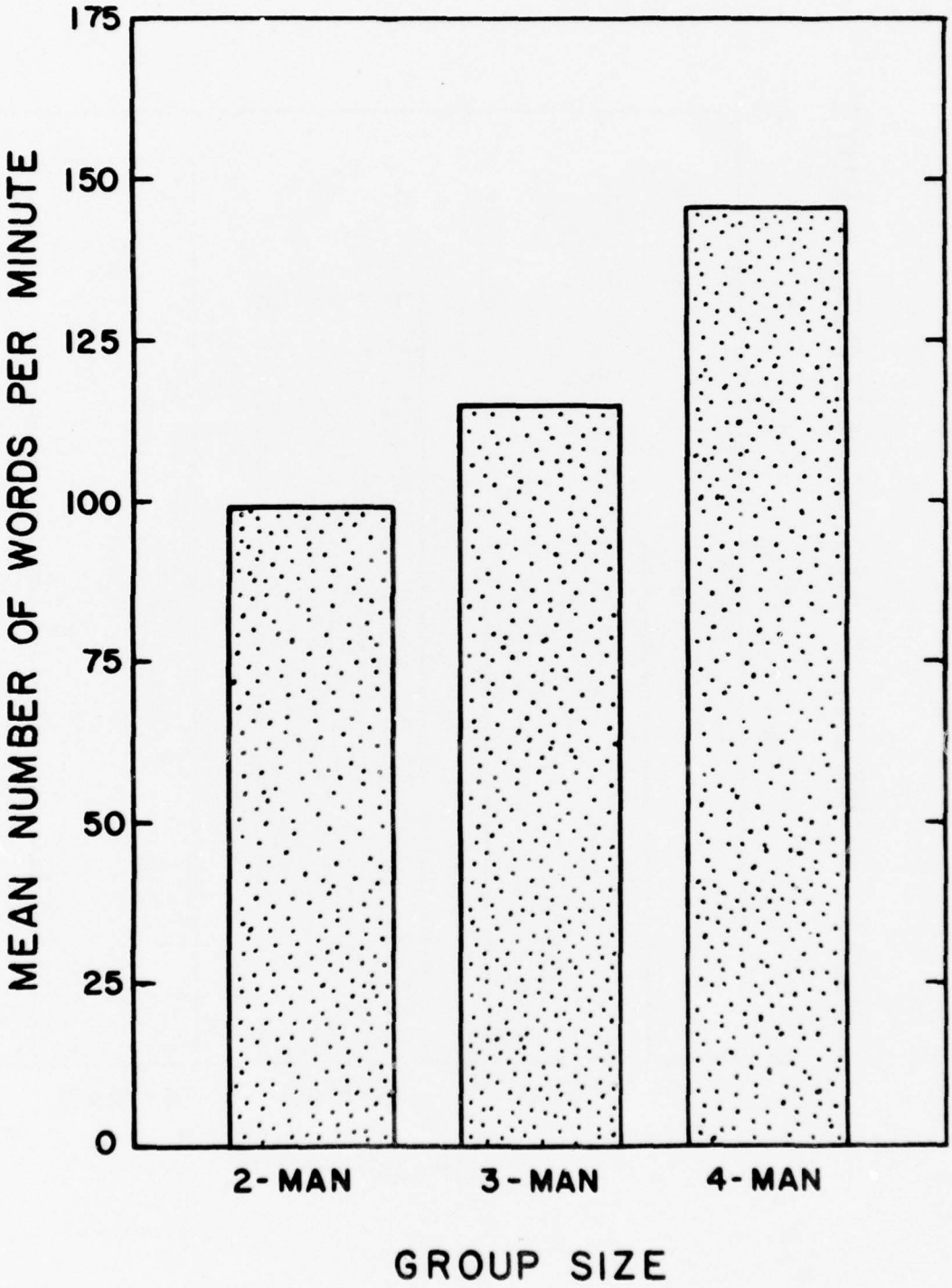

Figure 10. Mean communication rates (words/minute) for each of the three

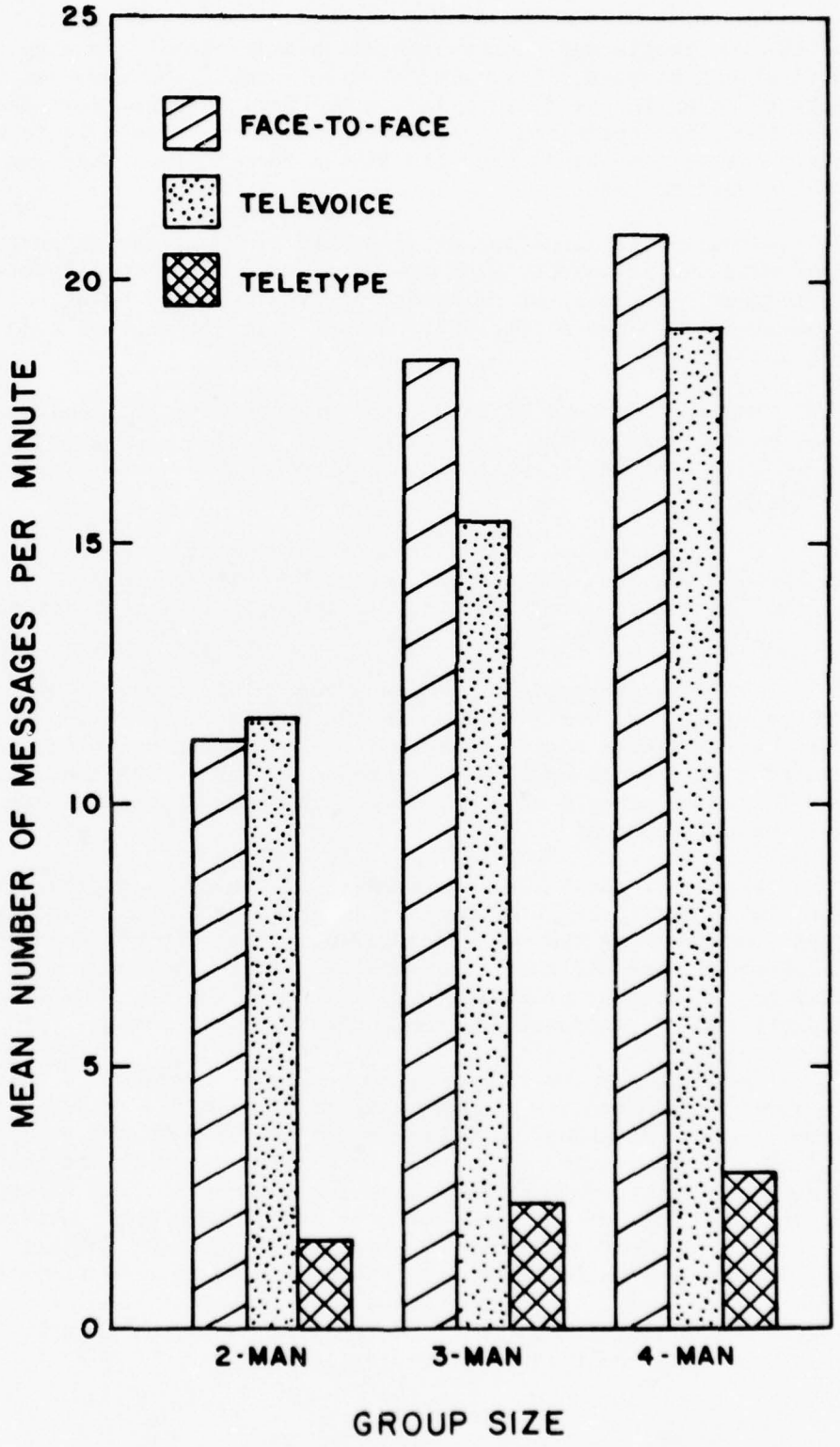

Figure 11. Mean communication rates (messages/minute) as a function of group size and communication mode.

however, two people may address remarks simultaneously to a third or fourth silent partner. This kind of simultaneous conversation is more likely to occur in the face-to-face mode where both speakers can turn toward the silent person(s). Indeed this was the case. There were 3374 occurrences of simultaneous speech in the face-to-face mode but only 1533 in the televoice mode.

Finally, with the larger group sizes, there was an increased likelihood that one or another member of the group might interject some form of agreement, approval, or disagreement with what was being said, while it was being said. Such short interruptions were, of course, counted as messages and words.

The explanations offered here for the increase in communication rates, measured in numbers of messages per minute, as a function of group size would also largely apply to communication rates expressed in numbers of words per minute.

In any case, the most interesting implication of all these findings is that although larger conferences do not necessarily take longer than smaller ones, there is clearly an increase in verbal information load in the larger conferences.

(4) Relative variability among messages. Coefficients of variation for each group were analyzed in the same way as all the other measures. A small mean coefficient indicates that the members of a group produced nearly equal numbers of messages; a large mean coefficient indicates that some members of a group generated disproportionately more messages than did others.

Figure 12 shows that the members of the two-man groups tended to share almost evenly in the number of messages produced. However, in the larger groups one or two of the conferees frequently produced considerably more messages than did their teammate(s). That is, one or more members seemed to dominate by producing more messages, whereas one or more other teammates tended to produce correspondingly fewer messages.

The data for the two-man groups should, however, be interpreted with some caution because they were artificially constrained. In the teletype mode, the number of messages communicated by the two team members could not differ by more than one. In the face-to-face and televoice modes, the numbers of messages by the two conferees could differ by more than one, but only if one conferee made one or more short utterances while his partner continued talking. On Line 12 in Table 3, Subject C for example, utters such a short message during B's message on Lines 8, 9, 10, 11 and 13. In the 3- and 4-man groups, on the other hand, the numbers of messages could differ because of overlapping messages, because one or more members actually communicated less, or both.

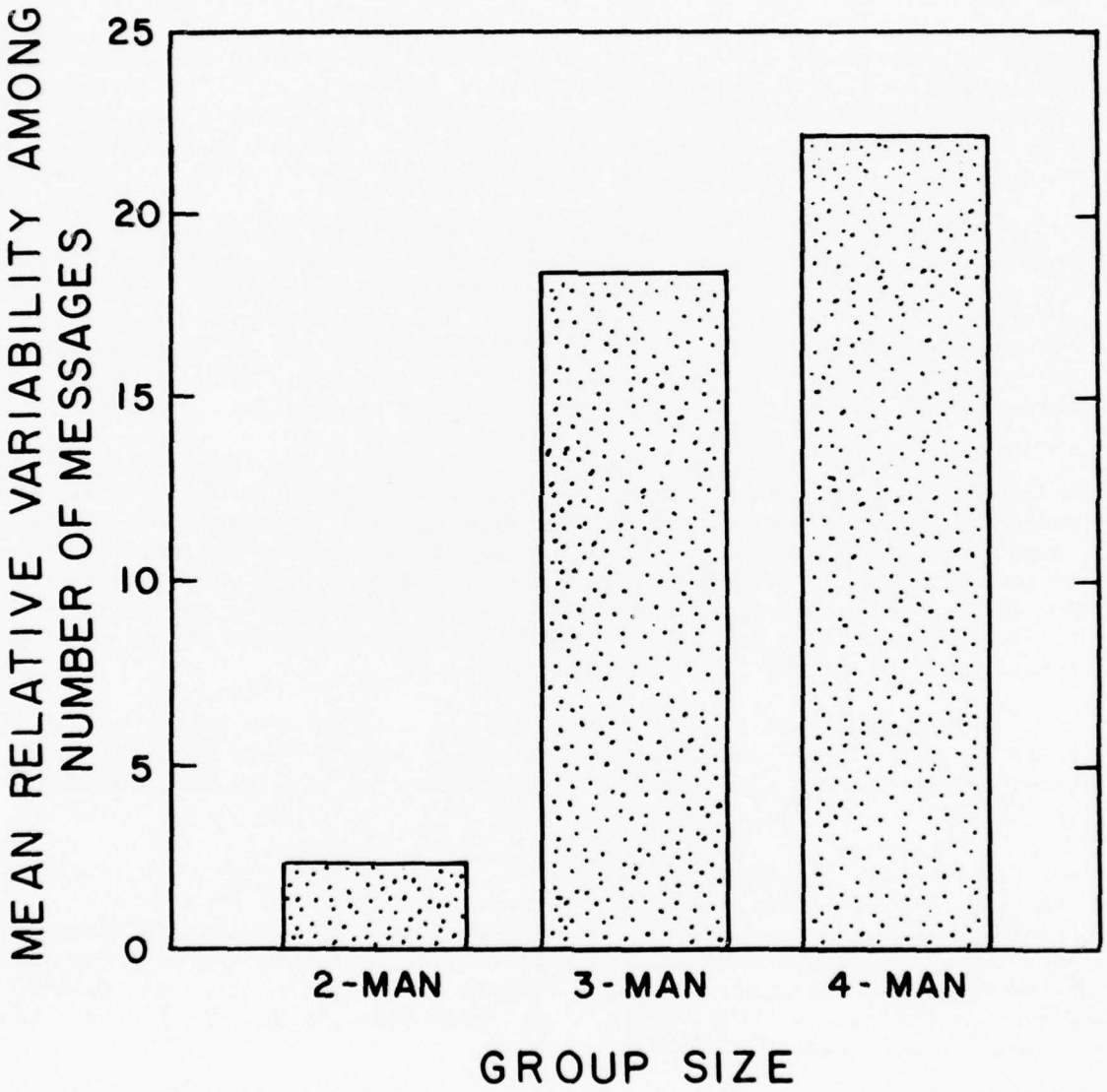

Figure 12. Mean relative variability among the number of messages used by conferees within groups as a function of group size.

Effects of Communication Mode. Communication Mode had a significant effect on all but two of the nine verbal measures (See Table 4).

(1) Number of messages. Groups that communicated in the face-to-face mode generated an average of 413 messages per conference; those in the televoice mode 269; and those in the teletype mode 82 (Figure 13 and Table 6). Both orthogonal comparisons of interest were significant. The two modes containing a voice channel produced significantly more messages than did the teletype mode ($p<0.001$, accounting for 81.2% of the variance among modes) and the face-to-face mode produced significantly more messages than did the televoice mode ($0.010<p<0.025$, accounting for the remaining 18.8% of the variance among modes).

These basic findings are much like those reported in earlier studies from this laboratory (Chapanis, 1975). However, the absence of any significant interactions with modes indicates that the differences among the numbers of messages in the three modes of communication hold for all three Group Sizes, all Problems, all three Days, and all the combinations of these variables that were tested in this study. The latter is a very significant extension of the generality of the earlier findings.

(2) Number of words. Except for a change in the values along the ordinate, the data for the number of words communicated in the several modes (Figure 14) is an almost perfect copy of that for the number of messages (Figure 13). Orthogonal comparisons again show the two voice modes to be significantly different from the teletype mode ($p<0.001$, accounting for 85.6% of the variance among modes) and the face-to-face mode significantly different from the televoice mode ($0.025<p<0.05$, accounting for the remaining 14.4% of the variance among modes).

Because of the similarity between the data for the number of messages (Figure 13) and those for the number of words (Figure 14), mean message lengths did not differ significantly among the several modes of communication.

(3) Communication rates. Figure 13 and Table 6 show that 54 percent more messages were produced in the face-to-face mode than in the televoice mode. Note, however, that these additional messages required only about 40 percent more time (Figure 3). As a result, the mean numbers of messages communicated per minute (Figure 15 and Table 6) do not differ very much for the two voice modes. Far fewer messages per minute were, of course, transmitted in the teletype mode.

Since the data for the number of words (Figure 14) are so similar to those for number of messages (Figure 13), communication rates expressed in terms of number of words per minute (Figure 16) are an almost perfect copy (except for the values on the ordinate) of communication rates expressed in messages per minute (Figure 15).

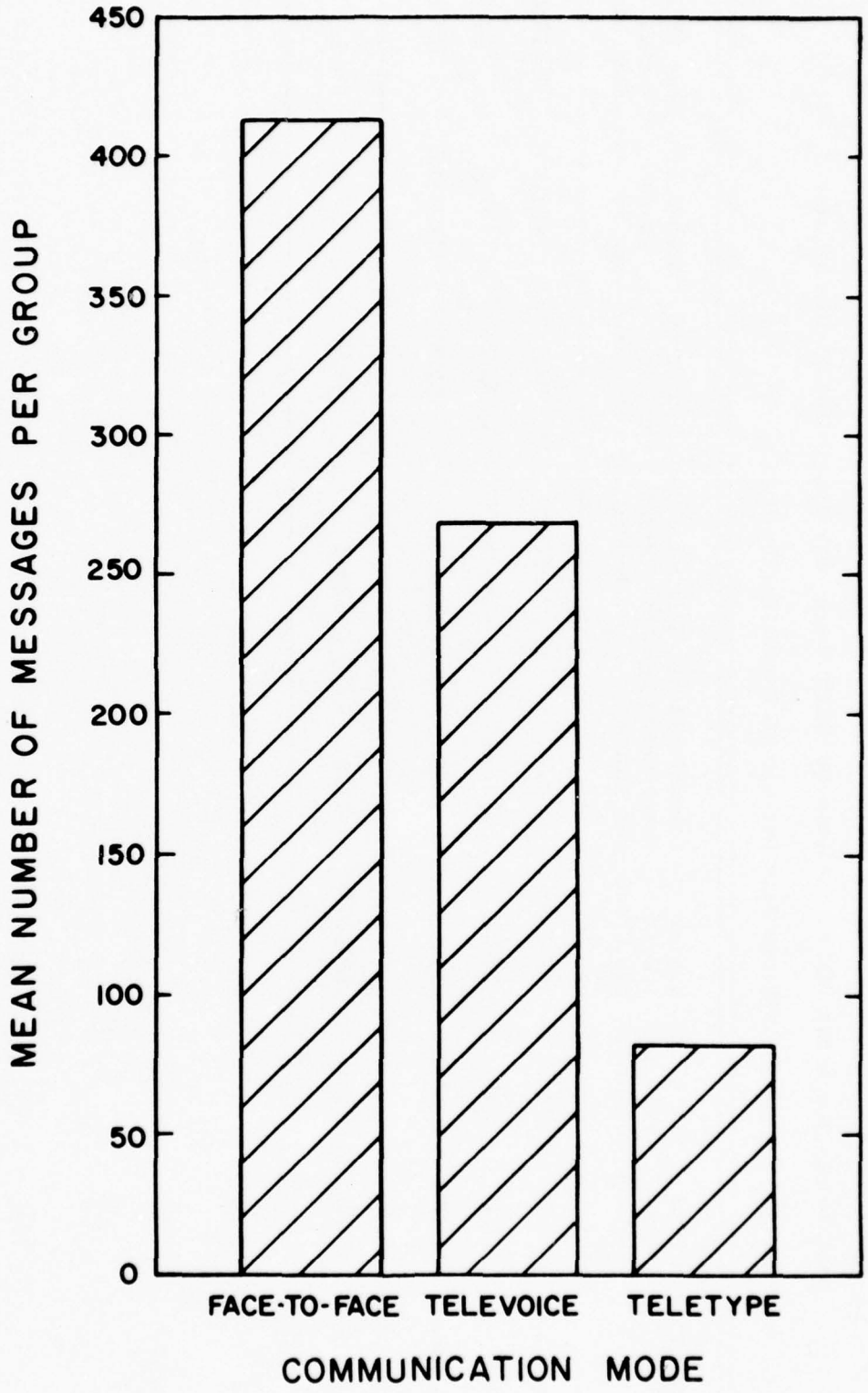

Figure 13. Mean number of messages per group as a function of communication mode.

Table 6

Mean Values for Those Verbal Measures in which there were Statistically Significant Effects Attributable to Communication Mode

Communication Mode	Time to Solution	Number of Messages per Group	Number of Words per Group	Communication Rate: Messages per Minute	Communication Rate: Words per Minute	Number of Messages per Person	Number of Words per Person	Mean Relative Variability among Messages
Teletype	36.1	82.1	725.5	2.4	19.7	27.7	255.1	10.4
Televoice	17.0	269.1	2914.6	15.4	166.4	84.3	931.1	13.6
Face-to-Face	23.6	413.2	4275.7	16.9	174.6	136.8	1433.7	18.4
Mean	25.6	254.8	2638.6	11.6	120.2	82.9	873.3	14.2

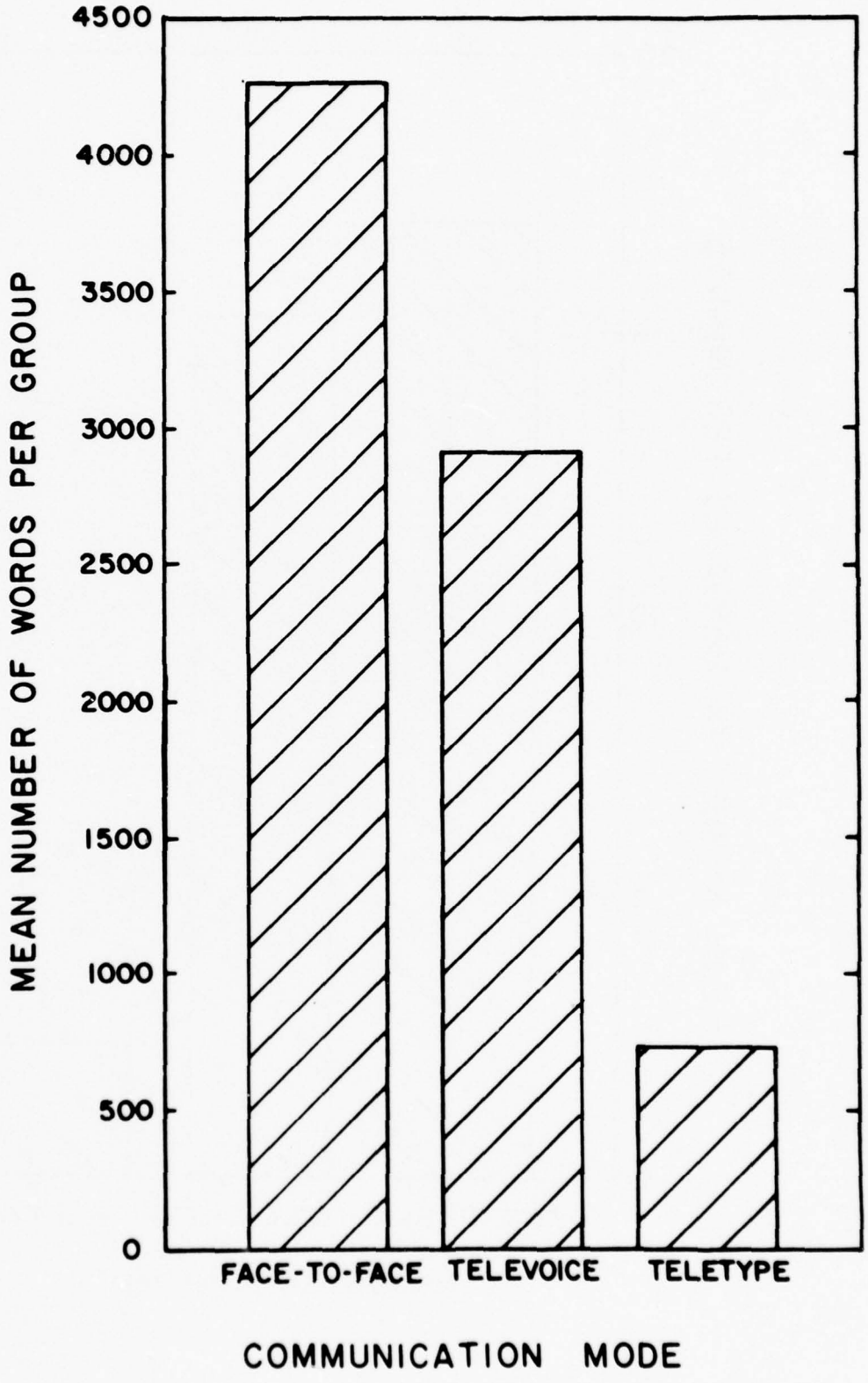

Figure 14. Mean number of words per group as a function of communication mode.

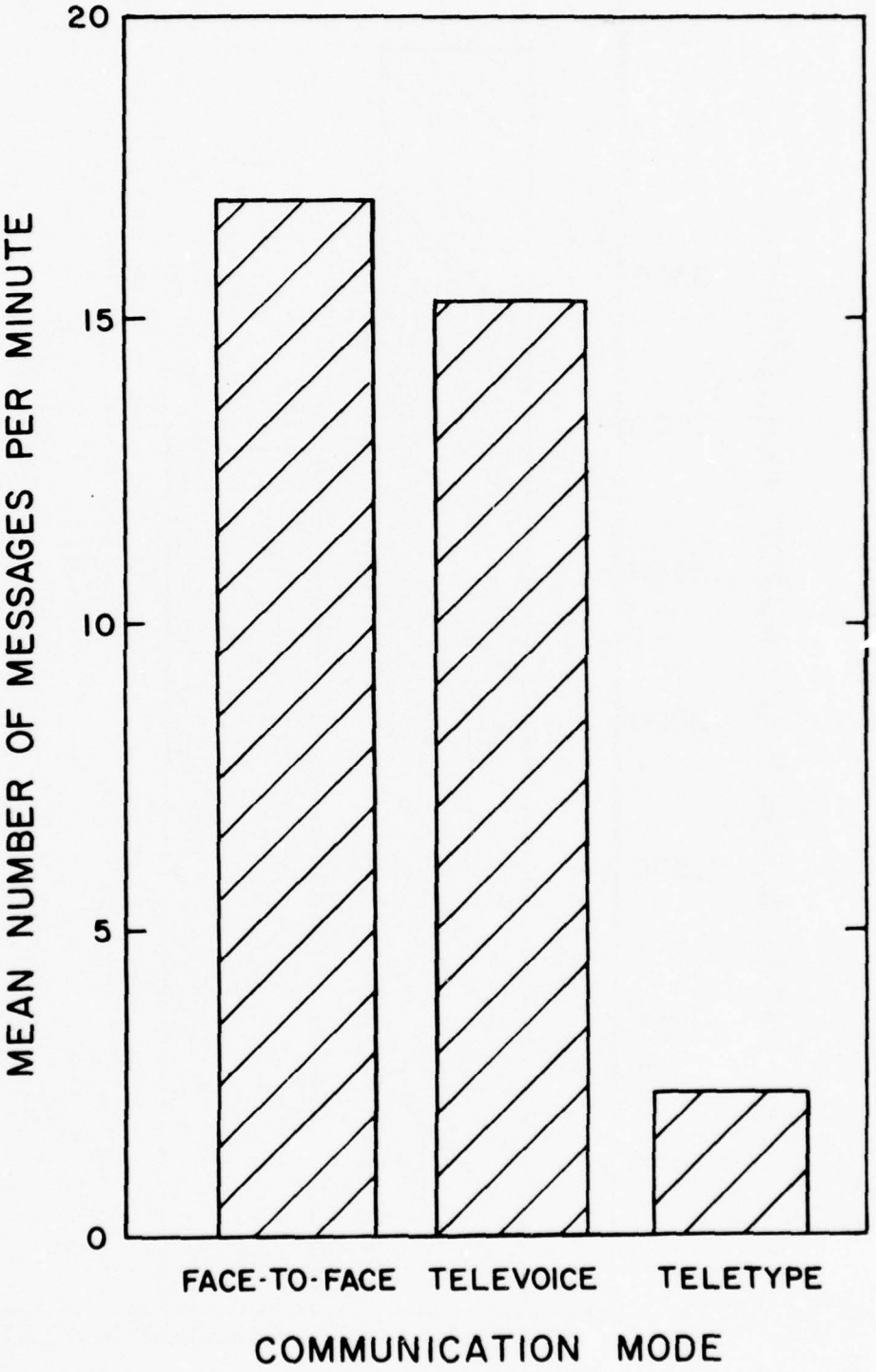

Figure 15. Mean communication rate (messages/minute) per group as a function of communication mode.

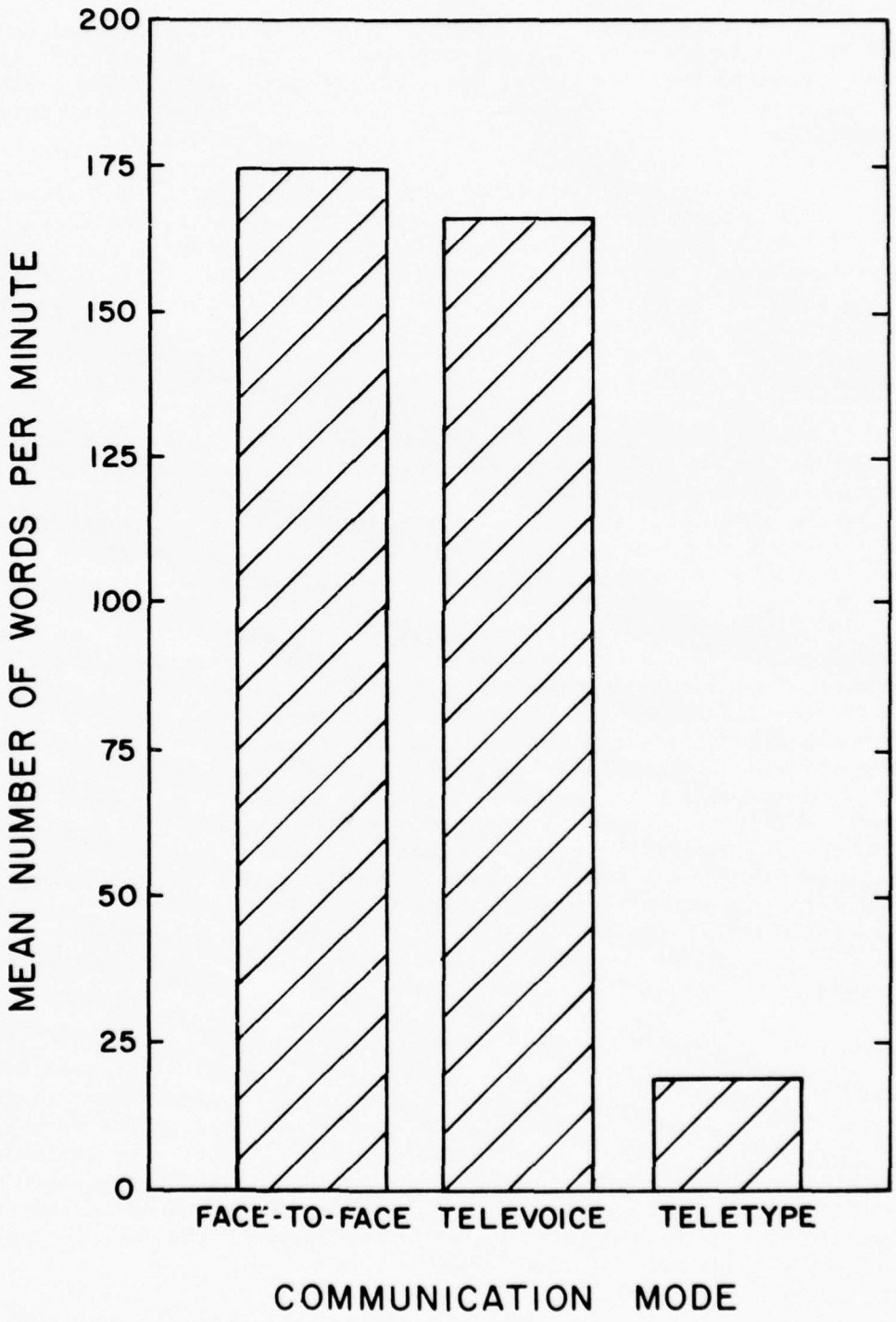

Figure 16. Mean communication rate (words/minute) per group as a function of communication mode.

For both measures of communication rate the orthogonal comparison of face-to-face + televoice vs. teletype was highly significant ($p<0.001$) and accounted for over 99% of the variance among modes. The orthogonal comparison of face-to-face vs. televoice was, of course, not statistically significant.

Some of the large differences in communication rates between the hard copy and the two voice modes is, of course, attributable to the simultaneous speech that was possible in the voice modes and not in the teletype mode. Such conditions occur in real life. It is rare to find more than two teletype machines at a communications terminal linked together with other terminals in such a way as to allow multiple simultaneous send and receive transmissions. Such set-ups are very costly and are generally only found in very large telecommunication stations.

Still, not all the difference in communication rates between the teletype and the two voice modes is accounted for by the presence or absence of simultaneous communication. People cannot type messages on a teletype machine as quickly as they can speak them over a telephone or in a face-to-face conversation, a finding that is well documented by the work conducted in the Chapanis laboratory (Chapanis, 1975).

(4) Number of messages and words per person. When the number of messages and number of words generated by each group was divided by the number of conferees in each group, the main effect of modes was still significant (Figures 17 and 18). Except for the numbers along the ordinates, the two figures are almost identical in appearance, as one might expect in the absence of significant differences in message lengths among the modes. The overwhelming contrast in both Figures 17 and 18 is between the two modes utilizing a voice channel and the teletype mode. For messages, the orthogonal comparison of face-to-face + televoice vs. teletype was significant at $p<0.001$ and accounted for 76.8% of the variance among modes. For words the corresponding figures are $p<0.001$ and 81.9%. The orthogonal contrast between the face-to-face and televoice modes was also significant at $0.01<p<0.025$ in the case of messages and $0.025<p<0.05$ in the case of words.

(5) Relative variability among numbers of messages. Figure 19 shows that conferees produced much more nearly equal numbers of messages in the teletype mode, somewhat less equal numbers of messages in the televoice mode, and widely disparate numbers of messages in the face-to-face modes. Only one orthogonal contrast was significant. The two modes containing a voice channel produced more variability among the numbers of messages than did the teletype mode ($0.025<p<0.05$, accounting for 64.5% of the variance among modes). The comparison between the face-to-face and the voice modes was not significant.

It is interesting that the relative variability among numbers of words was not significant, although, to be sure, the conferees produced

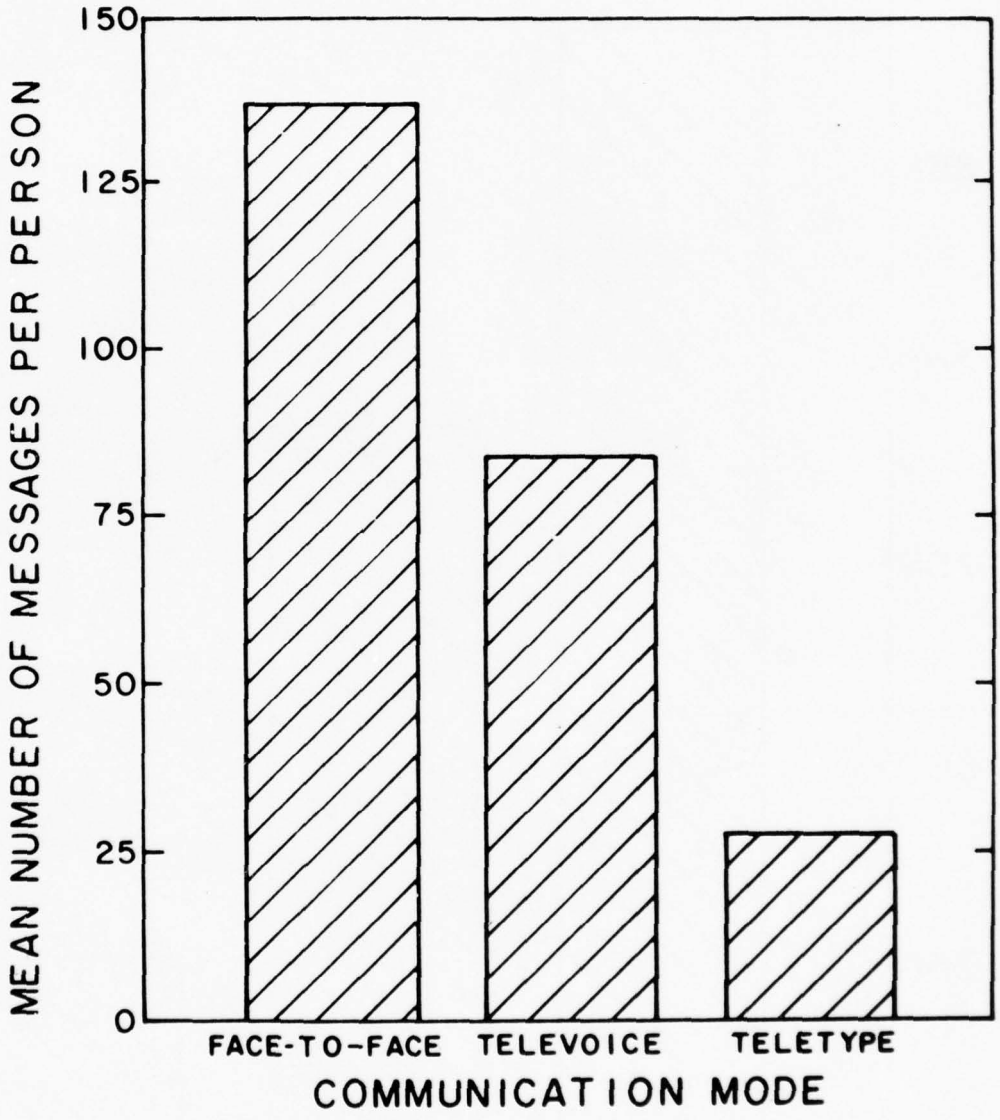

Figure 17. Mean number of messages per person as a function of communication mode.

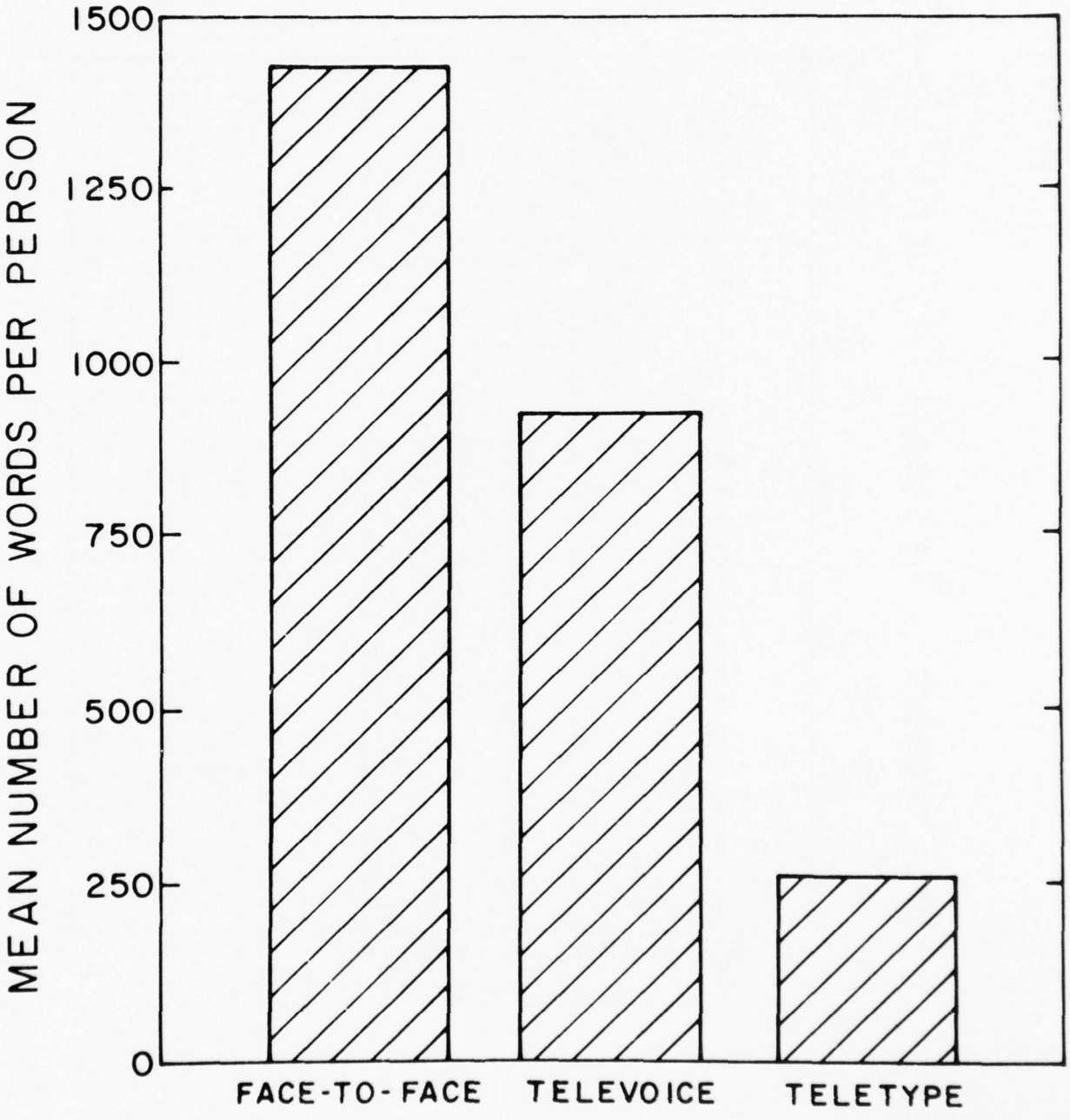

Figure 18. Mean number of words per person as a function of communication mode.

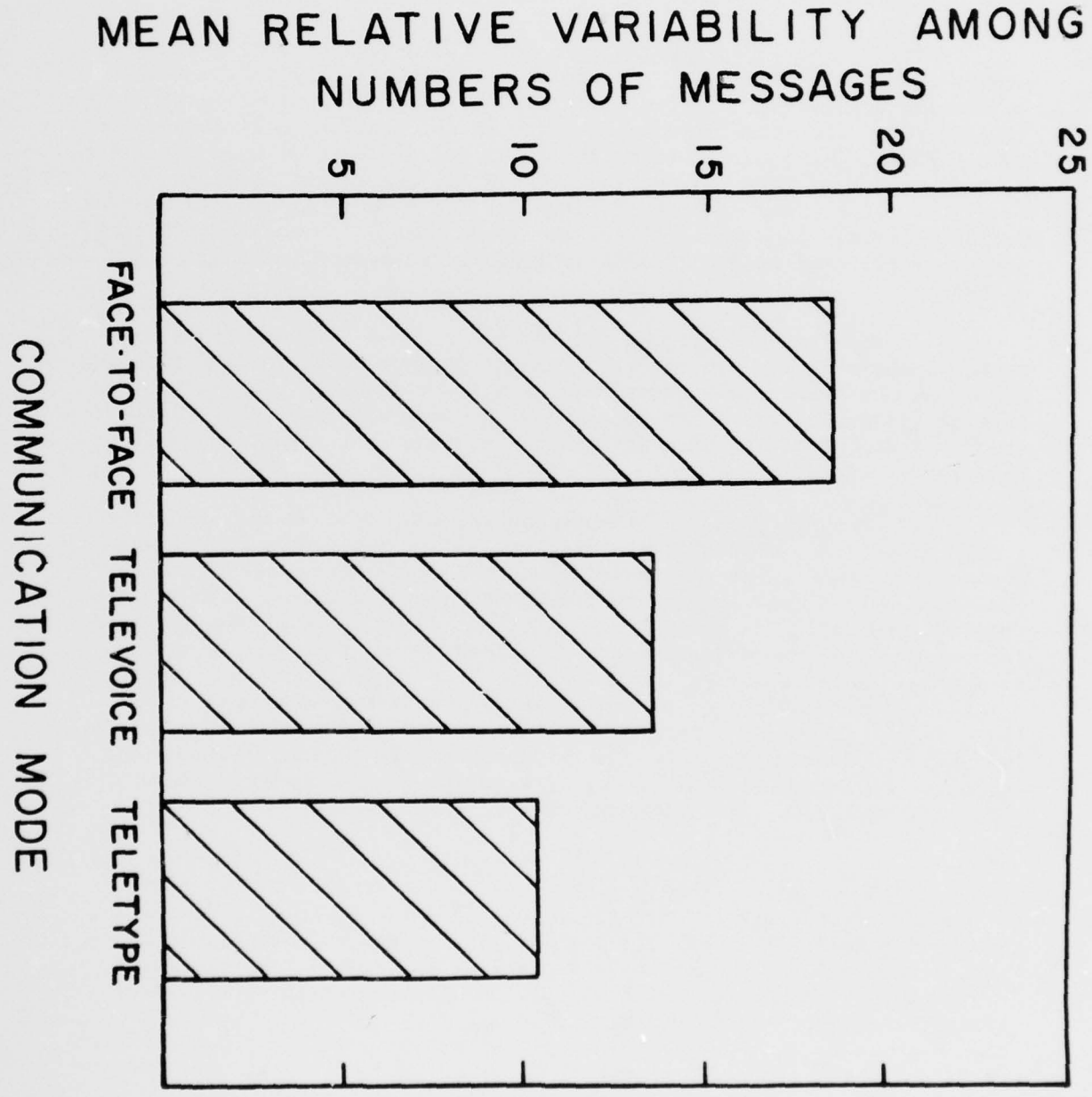

Figure 19. Mean relative variability among the number of messages used by conferees within groups as a function of communication mode.

more nearly equal numbers of words in the teletype mode than in either of the two voice modes.

Effects of Days. Differences attributable to Days (sessions) were significant for four of the nine verbal measures (Table 4).

(1) Number of messages and words. The number of messages and the number of words produced per conference decreased regularly from session to session but only the latter effect was statistically significant (Figure 20). The apparent non-linearity is not statistically significant. Except for a change in values along the ordinate, the data for the average number of words per person (Figure 21) are almost identical with those for the average numbers of words for the group. It appears that as subjects learned to work together, the group as a whole and the subjects individually required fewer words to reach agreement on successive days of test.

There was a significant interaction between Days and Group Size in the numbers of words used by the groups (Figure 22). The 2- and 4-man groups showed a regular decrease in the numbers of words used in successive sessions, but the 3-man groups deviated somewhat from that regular trend. I am not inclined to attribute much practical significance to this interaction.

(2) Message length. Mean message lengths also varied significantly on successive Days of test (Figure 23), but the data do not show a monotonic trend. The irregular appearance of the data can be partly explained by the data showing the interaction of Communication Modes with Days (Figure 24). The largest single effect shown there is the increase in mean message length between the first and second sessions in the teletype mode. Another way of looking at the data is to say that in the first session, messages in the teletype mode were much shorter than those in the other two modes. In the second and third sessions message lengths were nearly equal for the three modes. In their first session, subjects used shorter messages in the teletype mode probably because of their unfamiliarity with the equipment.

(3) Group Size X Mode X Days interaction. As has already been observed, the average number of words per person did not differ significantly for the various Sizes of Group (Figure 7), but did differ for the three Modes (Figure 18) and for the three Days of test (Figure 21). The interaction among those three variables, is, however, very complex (Figure 25), with many deviations from the simple effects of the three variables singly. As one example, although in general the number of words per person decreased from session to session, this was not true for the 3- and 4-man groups in the teletype mode. As another example, in the teletype mode, the 2-man groups produced the largest number of words

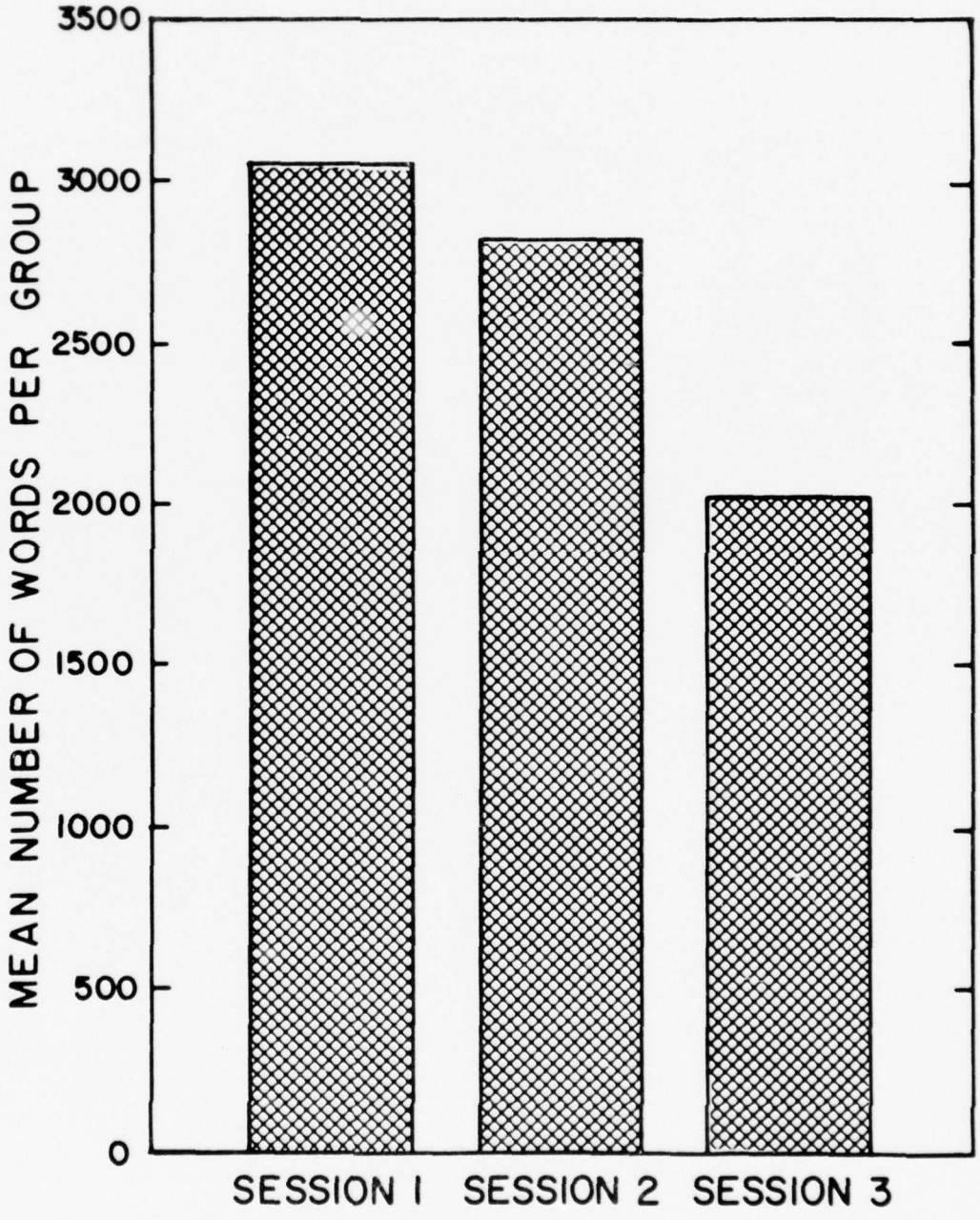

Figure 20. Mean number of words per group in successive problem solving sessions (Days).

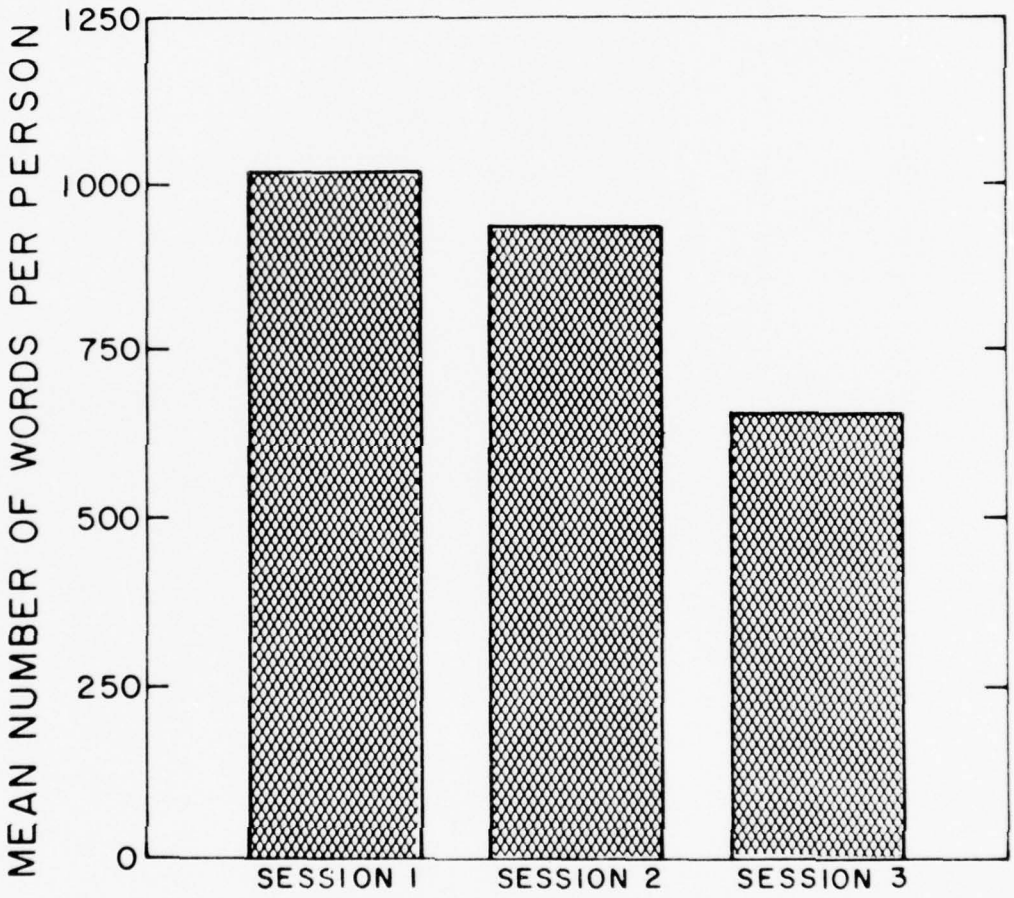

Figure 21. Mean number of words per person in successive problem solving sessions (Days).

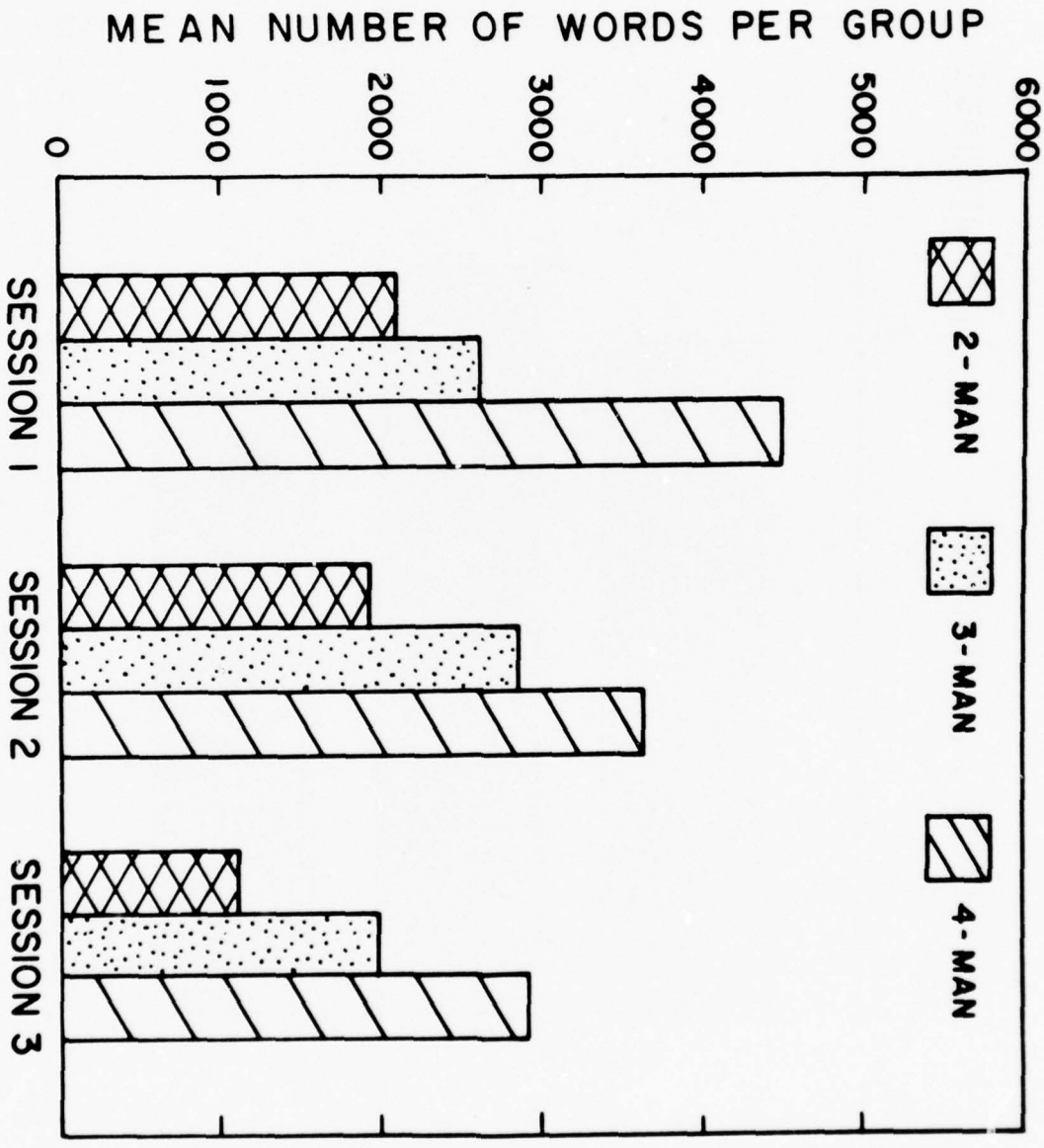

Figure 22. Mean number of words per group as a function of group size and problem solving sessions (Days).

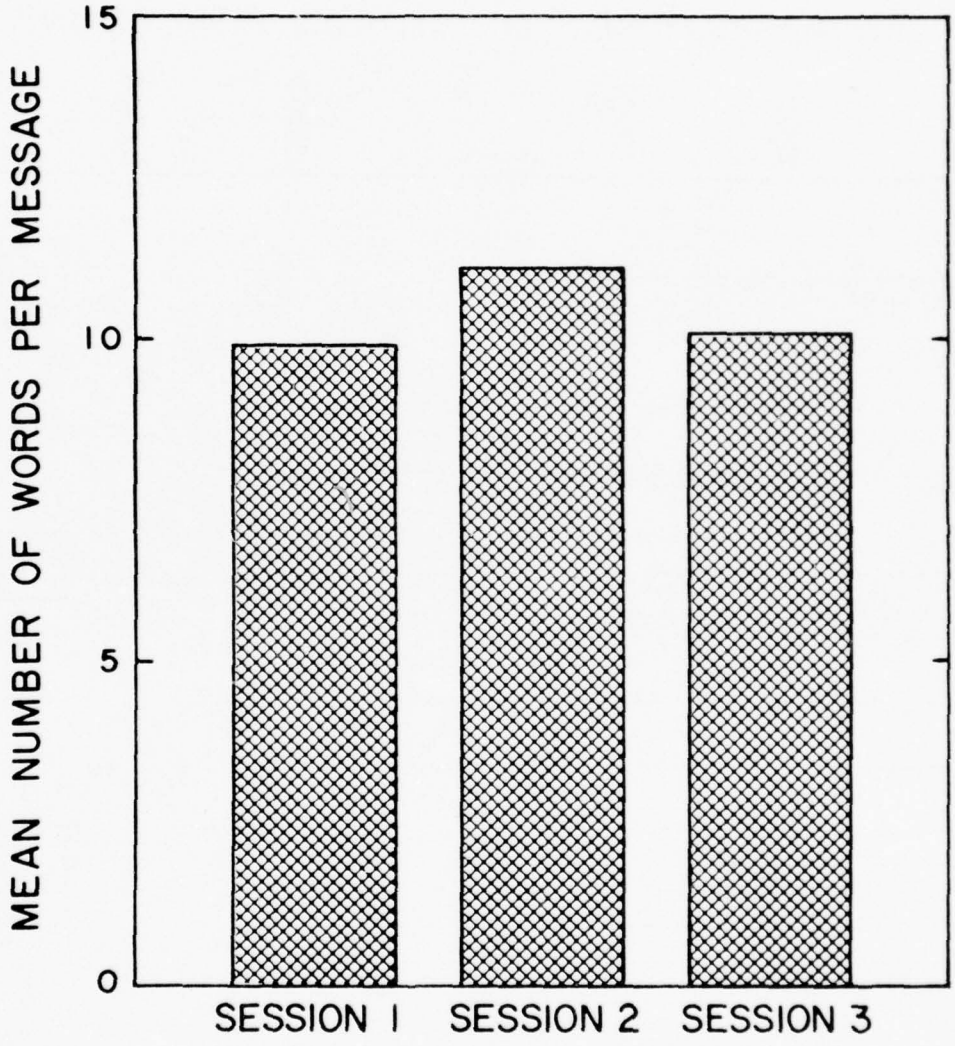

Figure 23. Mean message length (words/message) per group in successive problem solving sessions (Days).

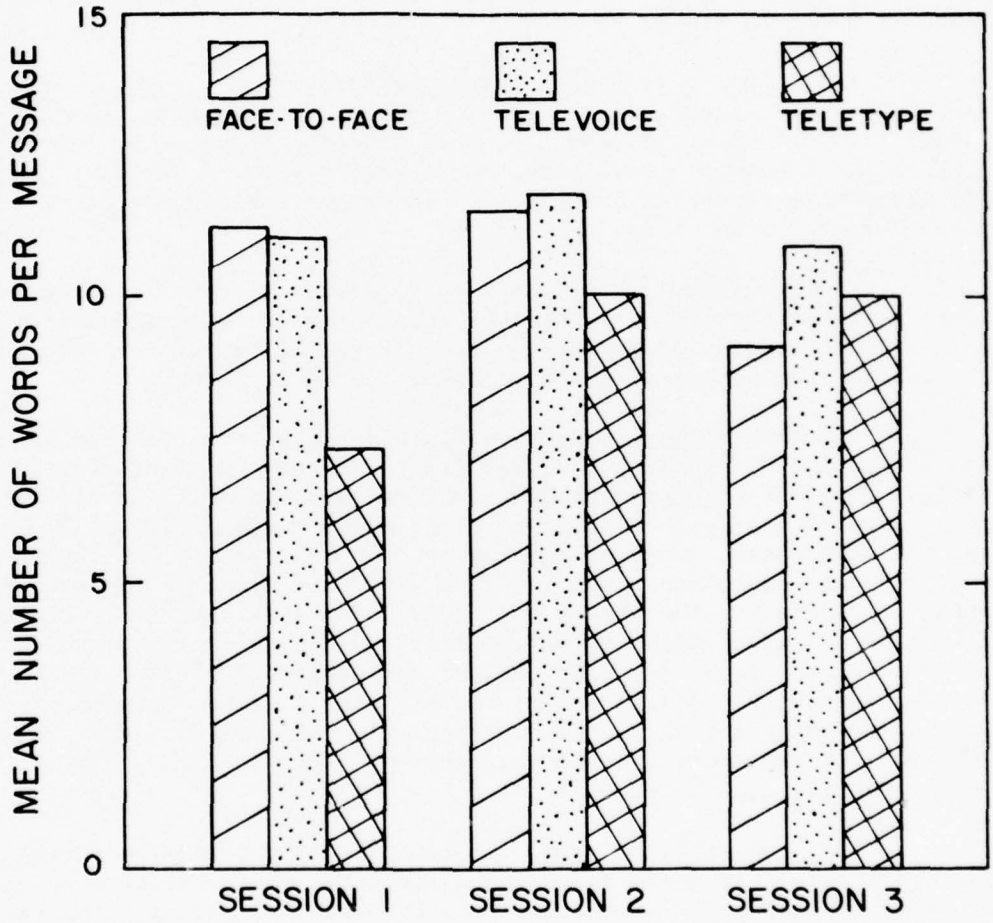

Figure 24. Mean message length (words/message) per group as a function of communication mode and problem solving sessions (Days).

during all three sessions; in the televoice mode, the 2-man groups produced the smallest number of words during all three sessions; while in the face-to-face mode the 2-man teams produced the largest number of words in the first two sessions, and the smallest number of words in the third session. As is sometimes the case with higher-order interactions, there appears to be no obvious explanation for these and still other effects shown in Figure 25.

(4) Relative variabilities among numbers of messages. Figure 26 shows the statistically significant effect among the mean relative variabilities for numbers of messages as a function of session. Although the data are not monotonic they show a tendency for individual conferees to share more evenly in the output of messages during Sessions 2 and 3 than during Session 1.

Problem effects. Although the problems were designed to be as much alike as possible, differences among problems were statistically significant for two of the nine dependent verbal measures: mean message length and the number of messages communicated per minute.

(1) Mean message length. Figure 27 shows mean message lengths as a function of Problem. The University Budget and Student Activities Budget Problems both concern budgetary matters and both are directly concerned with life on a college campus. The National Issues Problem, on the other hand, concerns matters of much wider scope. Orthogonal comparisons were planned accordingly. The comparison of the National Issues Problem vs. the University Budget + Student Activities Budget Problems was significant ($0.01<p<0.025$) and accounted for 86% of the variance among Problems. The comparison between the University and Student Activity Budget Problems was not significant. Students tended to use slightly shorter messages in arriving at consensus agreements on the two problems that involved matters more immediately related to their interests and experience.

(2) Communication rate. Unfortunately, the interpretation advanced immediately above about the differences among the three problems does not appear to be consistent with the data on communication rates (Figure 28). The mean number of messages communicated per minute during the solution of the National Issues Problem is almost exactly midway between the data for the two more similar student-oriented problems. The only significant orthogonal comparison was that between the two university problems ($0.01<p<.025$) which accounted for 98% of the variance among Problems.

Of the three problems, the Student Activities Budget Problem is closest to student interests and experience. The data seem to suggest

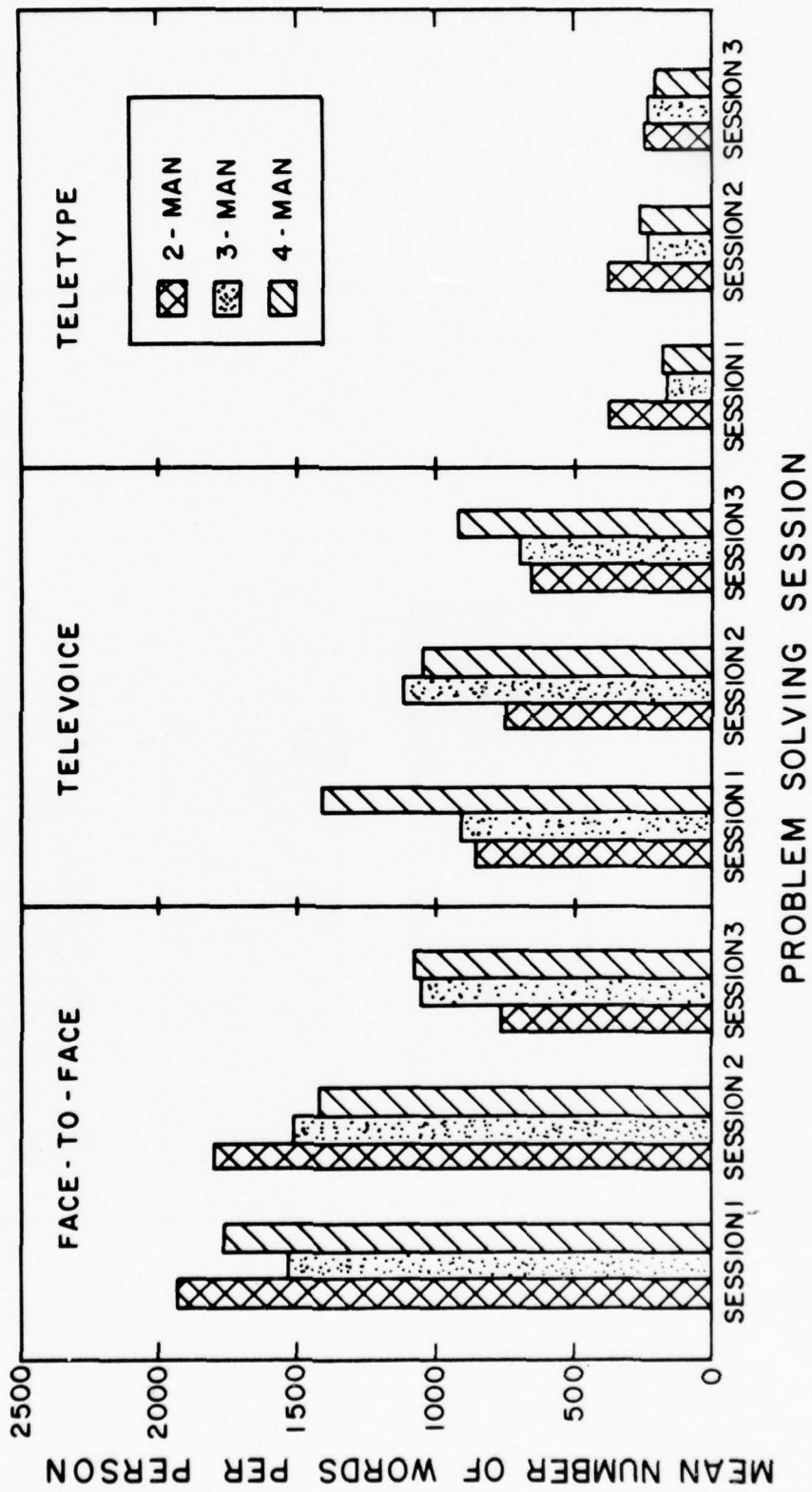

Figure 25. Mean number of words per person as a function of Group Size, Communication Mode and problem solving sessions (Days).

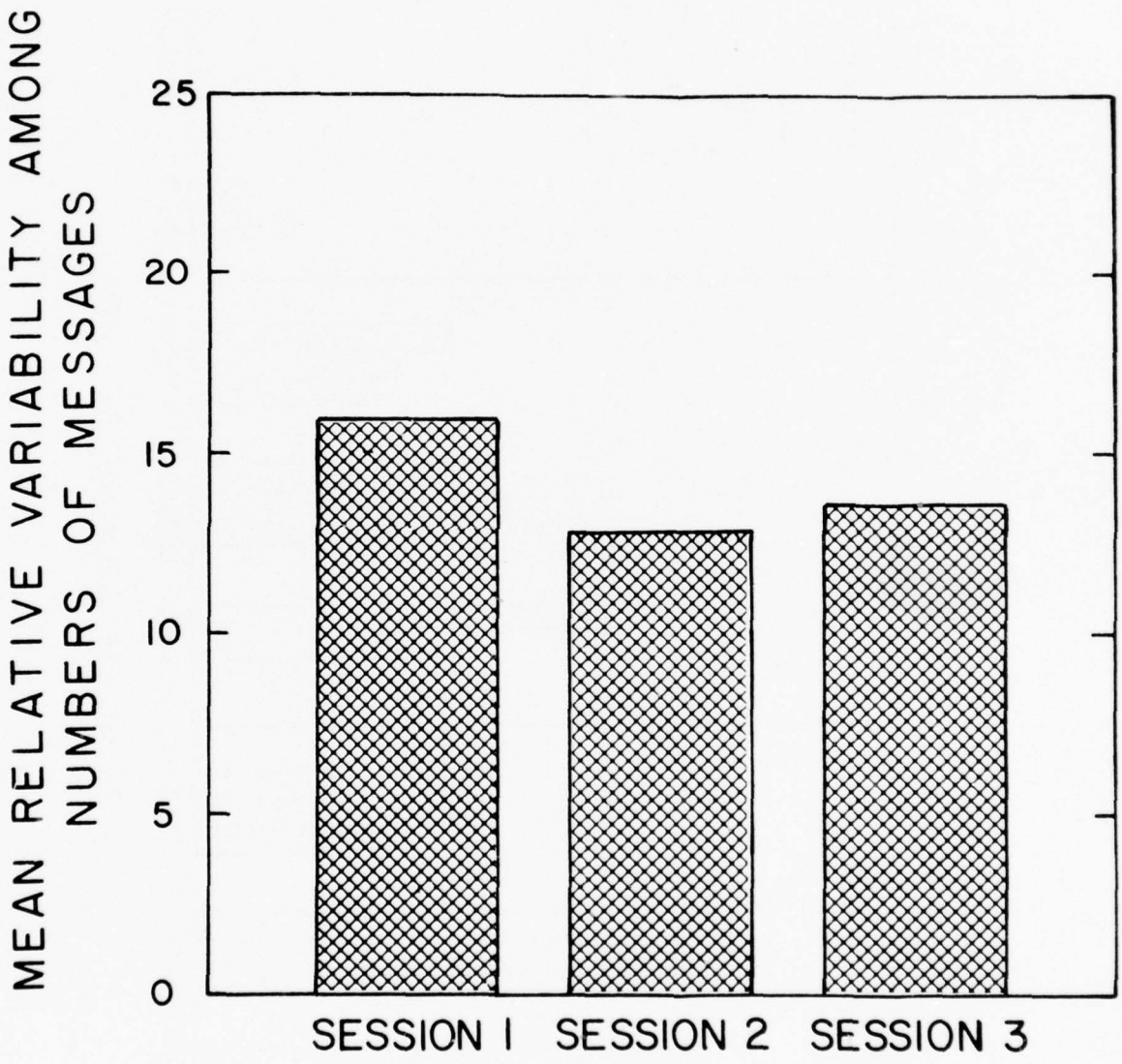

Figure 26. Mean relative variability among the number of messages used by conferees within groups as a function of problem solving sessions (Days).

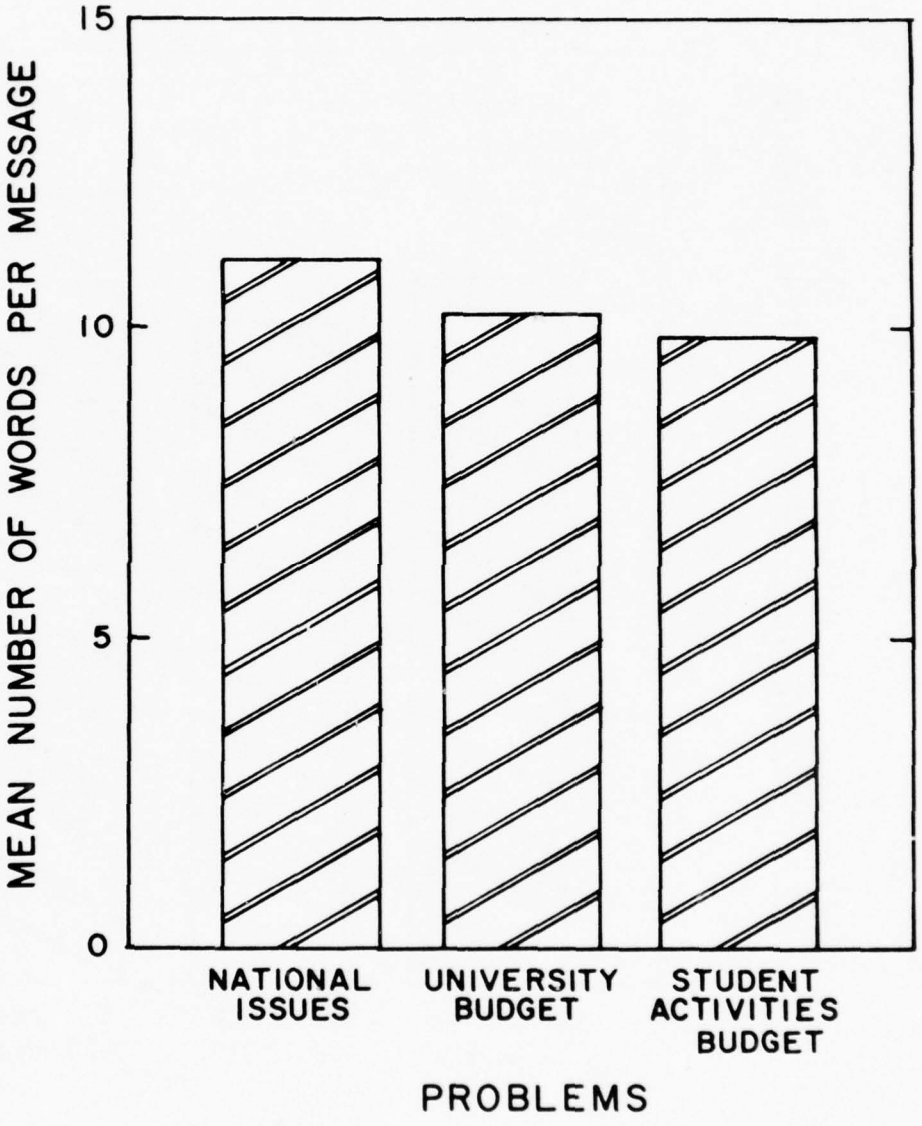

Figure 27. Mean message length (words/message) per group for the three problems.

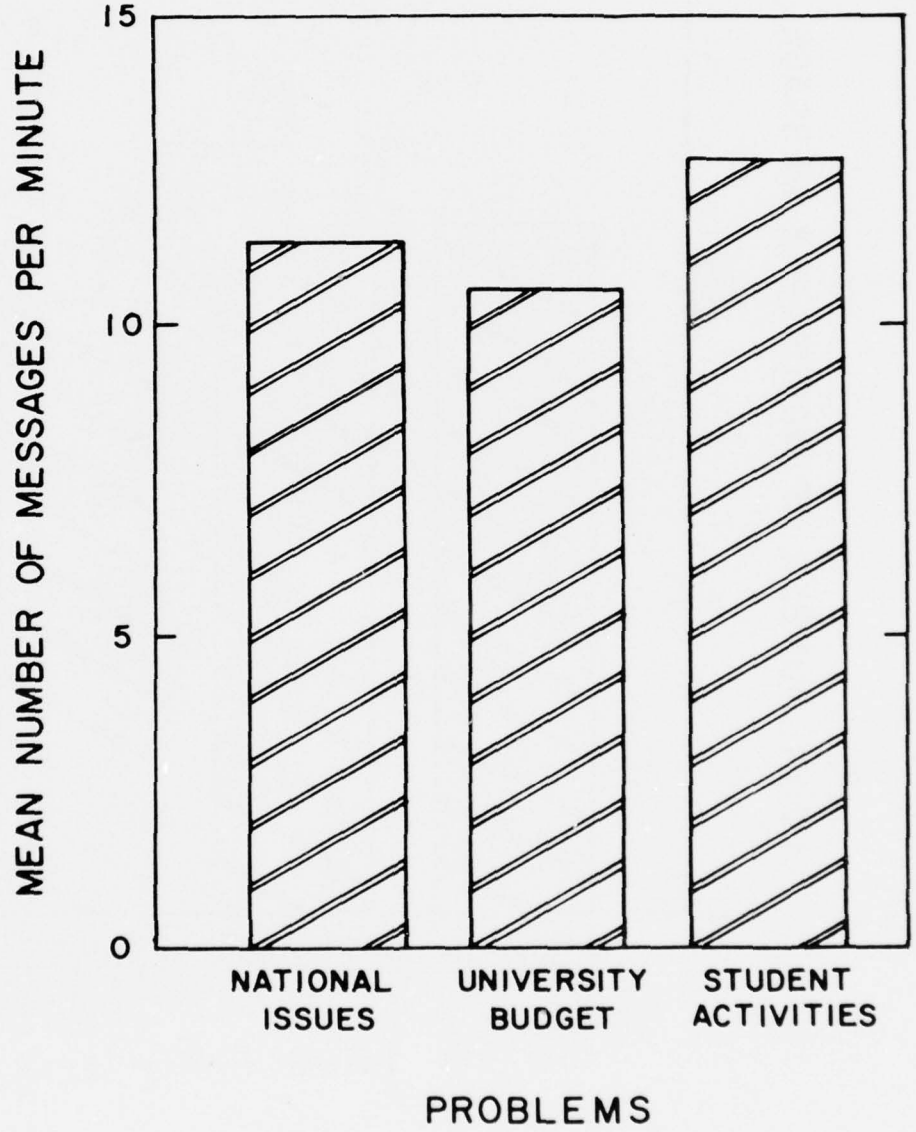

Figure 28. Mean communication rate (messages/minute) per group for the three problems.

that messages are shortest and communicated most rapidly for that problem than for any of the others. However, the differences among the problems are by no means as consistent as I had hoped they would be. Much more important is that the significant differences among problems are few in number and those that are significant are much smaller in size than those attributable to other main effects in this experiment.

(3) Higher-order interactions involving Problems. As has already been stated, the number of words communicated by the groups increased systematically as Group Size increased from 2 to 3 to 4 (Figure 5). Further, the greatest number of words was used by groups in the face-to-face mode, the next greatest in the televoice mode, and the smallest number in the teletype mode (Figure 14). There were no significant differences among the numbers of words used for the solution of the three problems. None of the three possible double interactions involving these variables was significant (Table 4).

The largest single component of the triple interaction involving these three independent variables comes from the data for the University Budget Problem in the face-to-face mode (Figure 29). The differences among the three sizes of group were much smaller in the solution of this problem in the face-to-face mode than were comparable differences among the solutions for the other two problems in the face-to-face mode or differences among the solutions to all three problems in the televoice mode. The second largest component of variance contributing to the triple interaction comes from the solutions to the University Budget and Student Activities Problems in the teletype mode. In both of the latter the data for the 3-man groups do not fall between those for the 2-man and 4-man groups as they do everywhere else in this figure.

Figure 30 reveals some similar deviations from the simple effects of the three variables singly for the numbers of words communicated per person. Prominent among them is the contrast between the results obtained with the University Budget Problem in the face-to-face and televoice modes. Other large deviations from simple effects are the differences among the solutions to the three problems by the three sizes of group in the teletype mode.

Because the problems in this experiment were rather similar in most respects and because the problems served primarily as vehicles for communication, I do not attach much practical importance to these two higher-order interactions.

Goodness of Solution

An analysis of the z-transformed correlations between the consensus rankings arrived at by each group and the pooled overall norm (see p. 34) yielded only one significant effect, that due to Problems

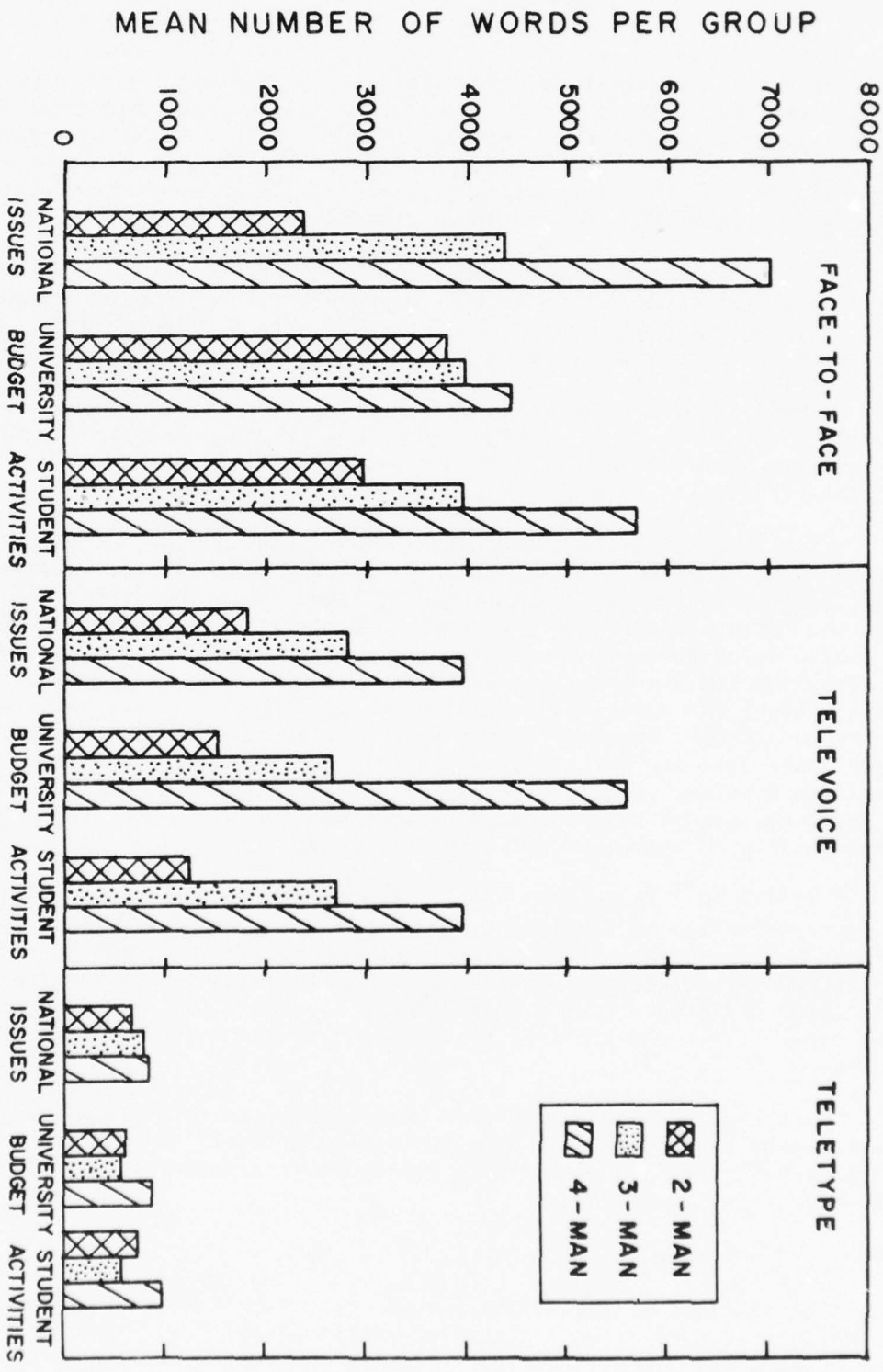

Figure 29. Mean number of words per group as a function of Group Size, Communication Mode and problem solving sessions (Days).

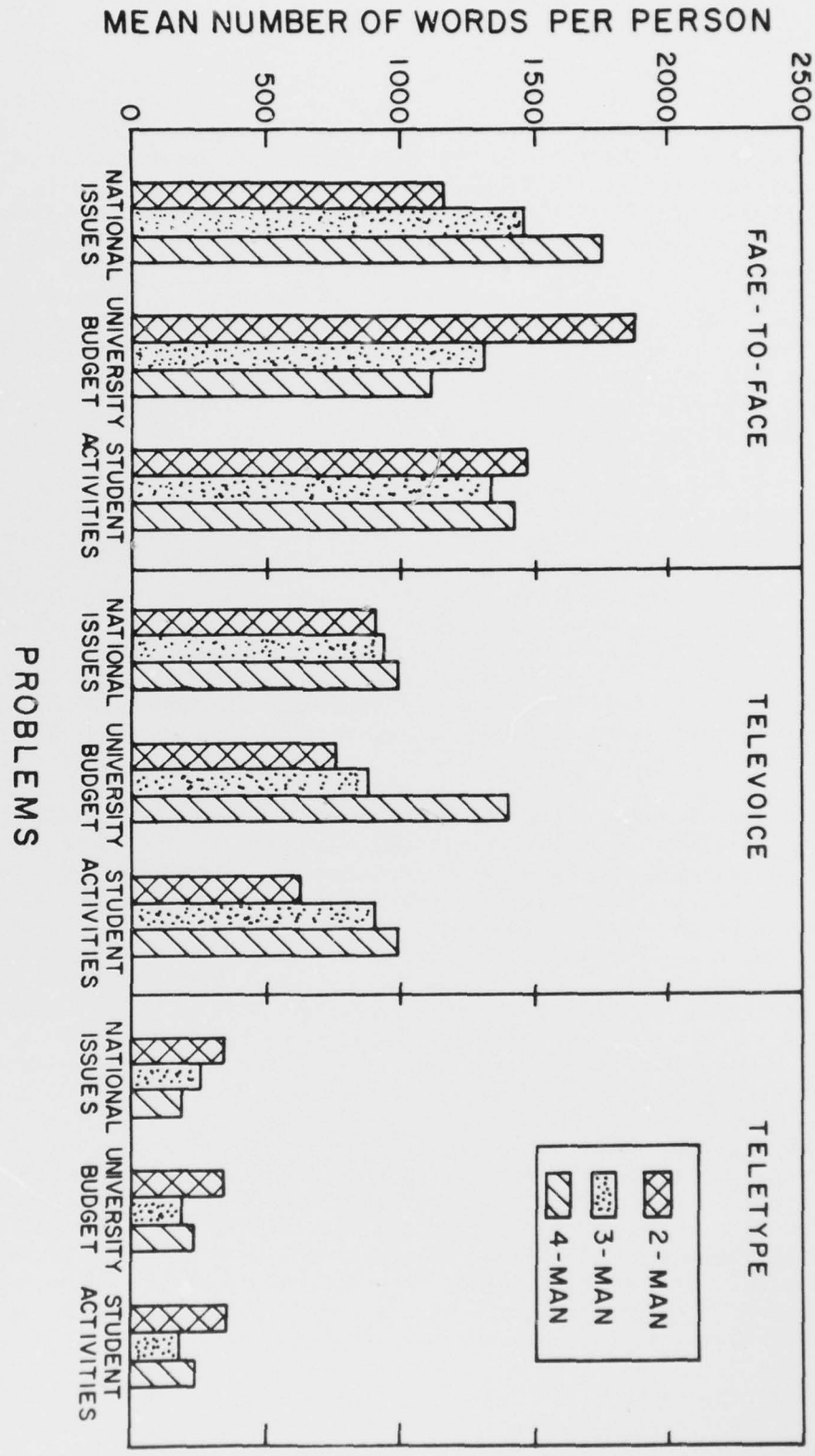

Figure 30. Mean number of words per person as a function of Group Size, Communication Mode and Problems.

(Table 4). On the average, group solutions to the National Issues Problem correlated lower with the norm (0.79) than did solutions to the University Budget and Student Activities Problem (0.87 and 0.88, respectively). The orthogonal comparison of the University Budget and Student Activities Problem vs. the National Issues Problem was significant at $0.001<p<0.005$ and accounted for 98 percent of the variance among Problems. The orthogonal comparison between the solutions to the two university-related problems was not significant. In short, teams of students were able to arrive at "better" solutions to the two problems that were more directly related to their immediate interests and campus experiences than they were to a problem involving national goals for which they might have been expected to have wider differences of opinion.

Even more important than the significant effects, are those that were not significant. Correlations between the consensus rankings of conference groups and the overall norm were not significantly affected by Group Size, Communication Mode, or successive Days of test. There is, in short, no evidence here that larger groups produced any better solutions than smaller groups, or vice versa. Nor is there any evidence here that the quality of the solutions was in any way affected by communication mode. The latter point is especially important in view of evidence from certain other studies (See for example, Morley and Stephenson, 1969) which suggest that communication mode has an important effect on the kinds of agreements people make.

To a considerable extent the interpretation of these findings rests on the validity of the overall norms that were used as criteria against which to judge the "goodness" or "accuracy" of conference group solutions. There are three possible sources of invalidity in these criteria: bias from the samples on which the overall norms were established, lack of precision in the objectives given each conference group, and statistical bias because the overall norms include data from the groups whose judgments are being correlated against the norms. Let me consider each of these points in turn and conclude with a positive argument for the validity of these norms based on internal prima-facie evidence from the data themselves.

Sampling bias. The conference groups in this experiment were told that they were to arrive at a ranking of the issues or items as the "average" undergraduate ranked them. However, the overall norms were actually based on the 81 male subjects who participated in this study and not on any reasonably random or stratified sample of subjects from the student body at Hopkins. How serious is this possible source of bias? Probably not very serious for purposes of these analyses. Although the overall norms may have been biased, they were at least stable.

Assume that one of the main variables had a significant effect on the sizes of the correlations against a "true" criterion, that is, a criterion based on a truly random sample of students. This would mean that

the average correlations for the three levels of the variable would differ significantly, and that, say,

$$M_{r_1} > M_{r_2} > M_{r_3} .$$

If now, each correlation were computed against an invalid, but perfectly reliable criterion (the overall norms based on the sample of 81 subjects actually used in this study) would the new set of three average correlations now become insignificant? Not necessarily. They might become

$$M_{r_2} > M_{r_1} > M_{r_3}$$

but the new means could and probably would still differ significantly. This line of reasoning would argue that bias attributable to the sample on which the overall norms were based should not necessarily obscure significant effects if there are any to be discovered. The analysis of variance, of course, is affected only by the differences among means, and not by their absolute magnitudes. Further, there is no inherent reason why correlations to a criterion other than the one used here should increase the error variability.

Lack of clear-cut objectives. Somewhat more serious is that the objective, or goal toward which the groups worked was not precisely defined. This was apparent from questions that were often asked by the subjects of each other during the conferences themselves: (a) "Were female students included in the poll?" (b) "Were representative proportions of students from each academic major (for example, pre-med, economics) polled?" (c) "Were proportional numbers of seniors, juniors, sophomores and freshmen polled?" (d) "Were equal numbers of students who receive financial assistance polled with those who do not?" It was left to the subjects themselves to determine what the experimenter meant by the "average undergraduate."

To the extent that different subjects worked with different implicit ideas of what constituted an "average undergraduate" and how such an average person would rank items, error variances would be increased. However, there is no reason to believe that any systematic biases would be introduced into the data from this source.

How serious is this source of error? There is really no way of estimating. However, note that the analysis did reveal significant differences among the mean correlations for the three problems and that the range between the highest and the lowest correlations was only 0.09. This would argue for no great loss in sensitivity in the data due to this source.

Bias attributable to non-independence of data in the correlations. A third possible source of error is that the consensus ranking of any group is correlated against an overall norm that includes data from the group itself. That is, the rankings of a four-man group are correlated against the data obtained from 81 subjects, but the 81 include the 4 men making up the conference group itself. In short, the two variables being correlated are not entirely independent.

This situation can be examined for its worst case. I have examined sets of rankings arrived at by two different four-man groups. The sets of rankings selected were those most deviant from the overall norms. Subtracting each set of rankings from the overall norms and rescaling the items for the remaining 77 subjects did not change the scaled order of the ten items, nor did it significantly affect the weightings for each item. On this basis, it seems reasonable to conclude that the data are not seriously affected by the duplication of data in the overall norms.

Evidence from the data themselves. Although the data on goodness of solutions should be interpreted with caution for the several reasons given here, there is also some reason to believe that they do in fact have some validity. There were significant effects attributable to problems and the directions of the differences found among the problems are at least consistent with what one would have expected intuitively. All this suggests that the data can be meaningfully analyzed and that the statistical tests are sensitive enough to reveal differences of reasonably small magnitude.

Another kind of evidence for the validity of the rankings of the items in the National Issues Problem comes from a comparison of the scaled values computed for the 81 subjects in this study with the scaled values for the same items computed with two other samples. In preparation for their study, Weeks and Chapanis (1976) conducted a survey among the students in two psychology classes (N = 49) at Towson State College in December 1973 (Sample A). Weeks and Chapanis then tested 80 subjects in their experiment during the spring of 1974 and computed scaled values for the same ten issues based on the data of those subjects (Sample B). Finally, there are the scaled values computed on the data of the 81 subjects in this study collected during the spring of 1975 (Sample C). The correlations among the scaled values from the three samples are:

$$r_{AB} = +0.95,\ r_{AC} = +0.91,\ r_{BC} = +0.82.$$

These correlations are reassuringly high and indicate that student views on these issues were quite stable over a time span of about two years and for students at two different institutions. All of which suggests that sampling bias is probably not a serious problem in this measure.

Questionnaire Data

Many of the questions in the questionnaire were open-ended and elicited responses consisting of short phrases or sentences. Even when a question could be answered with a simple "yes" or "no," amplifying comments were always solicited and sometimes made. For these reasons, the questionnaire data are largely qualitative and do not easily lend themselves to succinct summarization. For the most part I have relied heavily on letting the subject's comments speak for themselves. However, some common themes seem to be apparent in the responses to several of the questions. In the latter instances, simple frequency counts indicate the amount of agreement among subjects. Not all subjects wrote an answer to

every question, and some subjects expressed two distinctly identifiable viewpoints to some questions. As a result, frequency counts do not always add up to the appropriate N. The N for each of the three communication modes is 27. The N for the 2-man groups is 18, for 3-man groups 27, and for 4-man groups 36.

No attempt was made to match an individual subject's opinion with his performance data.

Telecommunication mode: Face-to-face. 1. In response to the question, "WHAT DID YOU LIKE ABOUT COMMUNICATING THIS WAY?" subjects described the mode with words such as informal, personal, relaxed, and spontaneous. Three of the 27 subjects commented that communicating face-to-face allowed conferees to pick up cues from facial expressions, gestures and tone of voice. Other subjects commented that this mode was better for understanding another person's point of view and that it allowed for an effective and rapid interchange of ideas, the easy formation of compromise, and the development of a spirit of cooperation. Some verbatim comments follow:

$G_8 S_2$: Face-to-face communication makes it easy for compromise and agreements.

$G_9 S_1$: Easy accessibility, picking up cues from facial expressions, more intimate conversations.

$G_{17}S_1$: It was pretty easy to see when someone was unsure about an answer. It was nice to see who you were talking with.

$G_{17}S_3$: I was able to see everyone: their reactions, facial expressions, how they reacted; because things were visible, it was good.

$G_{25}S_3$: More personal, and better for understanding another's point of view.

2. In answer to the question, "WHAT DIDN'T YOU LIKE ABOUT COMMUNICATING THIS WAY?" eleven subjects said there was nothing they didn't like. Three subjects mentioned feeling uncomfortable with the knowledge that their conversations were being tape-recorded. Fourteen subjects wrote varying comments which included observations on the difficulty of holding a conversation with 3 or 4 people at once; the influence that a majority can exert on a minority; the uneasy feeling of communicating with people whom they did not know very well; and the lack of novelty in communicating face-to-face. Verbatim comments follow:

$G_8 S_2$: There was not much time to think out what you were going to say.

G_9 S_1: Non-anonimity (sic) when in a disagreeable position.

$G_{25}S_1$: Personality becomes far too easily a factor of discussion and debate. It is easy to play upon people's emotions and sentiments, and it was too easy for one person to succumb to the will of the other three, whether it was actually expressed or only felt. The flow of conversation alone could be used to sway people; and the result was that they compromised themselves often too easily.

$G_{25}S_4$: Nothing - this is certainly the most effective way to state your views and get feedback.

$G_{26}S_4$: You can't easily hold a conversation with 3, to say nothing of 4 people. Somebody has to sit out. But, then there are no alternatives which would present the same advantages.

$G_{27}S_1$: It can get a trifle tedious arguing over points I considered insignificant. However this was part of the structure of the experiment and was not easily avoided.

3. When asked the question, "HOW WOULD YOU FEEL ABOUT CONDUCTING THESE SAME DISCUSSIONS OVER THE TELEPHONE IN WHICH CASE YOU WOULDN'T HAVE BEEN ABLE TO SEE ONE ANOTHER?" 17 of the 27 subjects indicated some apprehensions about a switch to a telephone conference method.

G_8 S_1: There probably would have been similar results although seeing a person does help in the art of compromise.

$G_{18}S_1$: Much harder - I use facial expressions to judge the other person's responses and feelings - Not as friendly either.

$G_{18}S_3$: I think it would have taken me longer to get into doing the experiment because I would have felt a little ill at ease.

$G_{25}S_1$: It would be very difficult, watching expressions was very much a part in determining where the mood was shifting. There would also be too little compromise. It's easier to say "no" to someone who you don't see.

$G_{27}S_1$: I think it would be rather difficult and ineffective. These discussions were structured for personal interaction which could not occur over the telephone.

$G_{27}S_2$: I would like to see who I'm talking to - it's hard to explain.

Only 8 of the 27 thought either that switching from face-to-face to telephone would not be detrimental or that it might actually be advantageous.

G_7 S_2: I think I would feel fine without seeing, if the problem had remained so simple.

$G_{27}S_3$: Couldn't intimidate anyone.

4. When asked, "HOW WOULD YOU FEEL ABOUT CONDUCTING THE DISCUSSIONS OVER A TELETYPEWRITER CIRCUIT IN WHICH CASE YOU COULD NOT BE ABLE TO SEE OR HEAR ONE ANOTHER?" 25 subjects wrote responses indicating how much more difficult they thought it would be to carry out these discussions via teletype as opposed to face-to-face.

G_8 S_1: The impersonality of this would make communications even harder. Reading a person's thoughts on a sheet of paper would limit you specifically to these printed words. You could not in any way judge what he is going to say by either his facial expressions or voice intonations.

G_8 S_2: I feel a lot of important information would be left out that is included in an oral conversation.

G_9 S_2: It would be less expedient due to slow typing speed, inability to change course in mid-sentence etc.

$G_{16}S_1$: It would be more difficult because of the total depersonalization. It would seem more difficult to become concerned with the other person's viewpoint or with the problem at all.

$G_{17}S_3$: This would have been difficult because seeing & hearing were so much a part of the experiment. But I would not be totally adverse to it either.

$G_{25}S_1$: Communications would become even more difficult, compromise harder to achieve, and it would cause a large increase in the time for each discussion. The amount of rhetoric would greatly increase.

$G_{27}S_2$: Arguing and hearing more than one opinion at a time (i.e., immediate feedback are useful). The way things are said (emotion, interaction) is important.

5. When asked, "CAN YOU GIVE EXAMPLES OF ANYTHING WHICH TOOK PLACE IN THESE FACE-TO-FACE CONVERSATIONS WHICH YOU THINK WOULD HAVE CHANGED SIGNIFICANTLY IF YOU'D BEEN COMMUNICATING OVER EITHER A TELEPHONE OR A TELETYPEWRITER CIRCUIT?" 7 subjects responded that they thought it

would take longer to solve problems in either a telephone or a teletypewriter conference.

Six subjects seemed to feel that they would have less confidence in the strength of statements made by people whom they couldn't see.

$G_{17}S_2$: I would have questioned all other suggestions and insisted that since I didn't know and couldn't see the person, I couldn't judge them.

$G_{25}S_2$: Would have been harder to tell how someone felt (weakly or strongly) about something.

Eleven subjects wrote answers that described affective characteristics of face-to-face conferencing which they thought would be changed by communicating in either of the two non-visual conference systems. Sample comments from these 11 subjects follow:

G_7 S_2: Any physical gesturing, nods etc. body language would have been absent. Language over the teletype would probably need to be well structured and grammatically true as it would not be heard.

G_8 S_1: In relation to the teletype of course we would not have been able to include our personal interpretations or small talk. We would, because of our inability to type effectively, been limited to only the base essentials.

G_9 S_1: TTY: Not able to pick up changes in the progression of another's ideas as rapidly. Necessity to formulate ideas solidly before communicating them, not during, to avoid uh's and ah's.

G_9 S_2: Over a teletype, I think the conversation would have been much more a question and answer type of communication.

$G_{16}S_1$: I think any levity and more personal references and anecdotes would have been eliminated.

$G_{25}S_3$: The facial expressions give a lot of info. on how strong a person's opinion is.

6. When asked, "IS THERE ANYTHING ABOUT THE MANNER OF COMMUNICATING WHICH YOU WERE ALLOWED TO USE IN THIS EXPERIMENT WHICH YOU WOULD LIKE TO SEE CHANGED IF YOU WERE USING IT IN AN OFFICE OR YOUR PLACE OF WORK?" 16 subjects either wrote "nothing" or made no comment at all. Seven subjects made some reference to either the table or microphone arrangements.

G_8 S_1: Just having the microphone and tables in front of us in a way restrained free conversation to a certain extent.

$G_{16}S_1$: Primarily the formality imposed by the microphones and the fixed positions around the table. Although some seating arrangement is obviously necessary, that used in this experiment seemed rigid.

$G_{16}S_3$: I would not like being recorded nor being observed.

$G_{25}S_3$: Use a smaller table for a sense of closeness and teamwork rather than having an "opposing" side.

7. In response to the question, "IF YOU AND YOUR PARTNER(S) WERE IN DIFFERENT CITIES AND HAD TO DISCUSS THE SAME ISSUES, WHAT ALTERNATIVE MEANS OF COMMUNICATION WOULD YOU CHOOSE IF YOU COULDN'T AFFORD TO MEET SOMEWHERE FACE-TO-FACE?" 22 subjects chose the telephone, 3 some form of audio-visual system, and 2 ordinary mails.

$G_8\ S_1$: Telephone - This I feel, would be the only effective means of communication in a situation as this, where immediate feedback must be provided by the one partner to the other in response to the ideas of the other partner.

$G_9\ S_1$: Telephone - Verbal cues are almost as easy to discern as facial ones in close rapid conversation when ideas are being formed and expressed at the same time. Problems are easier to solve than if you were typing questions, statements etc.

$G_{16}S_1$: Probably: (1) telephone, or (2) handwritten letters. (1) "It's the next best thing to being there" i.e. not as good as face-to-face but at least some personal interaction and vocal expressions to judge feelings. (2) With longer time between letters there would be more time for thought and handwritten seems more personal than typed.

$G_{18}S_3$: Telephone - because I think a telephone would place the least restrictions on the speakers and once one got used to talking on it he would feel as relaxed as if he were talking face-to-face.

$G_{27}S_2$: Four way hook-up telephone. I think it's important that everybody hear everything especially the way things are said.

$G_{25}S_1$: Letters - The use of letters and/or written statements. Precision of statement could be achieved and rhetorical. And subtle written persuasions are more easily achieved. Comparison, with a great deal of time for consideration is also achieved.

Communication mode: Televoice. 1. In response to the question, "WHAT DID YOU LIKE ABOUT COMMUNICATING THIS WAY?" the televoice mode was described by such adjectives as: quick, fast, efficient, effortless, fun, and relaxing. Four subjects suggested that since they were not allowed to see one another, they were able to devote more of their attention to the problem itself and less to their partners.

G_4 S_1: I didn't have to concentrate my attention on my partner. I could concentrate better on the problem. The newness was intriguing to me.

G_4 S_2: Not having to worry about the visual impression you are making (body posture, physical position etc.).

G_6 S_1: I could be physically inattentive, while maintaining a "full" contact. Also verbal communication is my forte, and the lack of visual allows for the reduction of side-tracking physical actions.

G_6 S_2: I felt less self-conscious in the beginning, and was able to concentrate my thought on the problem.

Four subjects indicated that since the solution to the problem necessitated agreement among subjects, they were required to pay more attention to what was being said in the televoice mode than they would have in a face-to-face situation.

$G_{22}S_3$: It made you concentrate more to pick everything out of the talking (i.e. emotion, inflection etc.).

$G_{23}S_4$: We had to ask each person his opinion. He couldn't be ignored, because since we couldn't see him, we had to hear from him.

The televoice mode seemed to provide enough detachment to prompt five subjects to comment upon it.

$G_{13}S_3$: It may have broken the ice a little, because sometimes it makes you nervous to talk face-to-face with a stranger, and this way everyone still had a little privacy.

$G_{22}S_4$: I did not have to look at the person. It is easier for me to dominate people vocally when I don't have to look at them. It is easy to make a point.

$G_{23}S_3$: Considering our topics, I liked avoiding a face-to-face confrontation, which could lead to open argument.

$G_{24}S_2$: We were a little detached from the situation. We could disagree easily without seeing each others' emotions.

2. In answer to the question, "WHAT DIDN'T YOU LIKE ABOUT COMMUNICATING THIS WAY?" the subjects' responses seem to fall into two major categories. About half of the subjects indicated that the televoice mode limited certain affective components of the communications.

$G_{13}S_2$: Not being able to see the other person hampered communication. It was hard to tell how enthusiastically someone was supporting a position.

$G_{14}S_1$: It was rather difficult to express oneself fully or comprehend another person fully without seeing his face or gestures.

$G_{14}S_2$: You couldn't see the reactions of what the other persons said, i.e. if he really agreed with you - or he was just going along with you to head off an argument. It's easy not to show what reactions you have towards an idea when people only hear what you say and don't see how you react.

$G_{24}S_2$: It limited your type of expression. Facial gestures and hands often convey a lot of meaning and we had to compensate for this.

Members of televoice teams consisting of more than two persons periodically experienced some confusion in readily identifying speakers.

$G_{23}S_3$: The lack of face-to-face contact. Sometimes not being able to correlate voice and face.

$G_{24}S_4$: Sometimes, you didn't know who was saying what.

$G_{23}S_4$: There was a problem in recognizing who would speak when. Often all four of us started to speak at the same time.

$G_{24}S_3$: Sometimes I would have liked to see people's faces so I would know who was saying what.

3. Many responses to the question, "HOW DID YOU FEEL ABOUT NOT BEING ABLE TO SEE ONE ANOTHER AS YOU NORMALLY WOULD IN A FACE-TO-FACE CONFERENCE TABLE SITUATION?" duplicated those to Question 1 and 2. Seven subjects seemed to feel that the inability to see one another was not particularly detrimental.

$G_4\ S_1$: It didn't bother me.

$G_{14}S_3$: I don't think face-to-face conference adds anything to this type of communication. The only situation a face-to-face confrontation is better in is emotional ones.

$G_{22}S_2$: I don't think it made too much of a difference after becoming used to it.

Nine subjects indicated that not seeing one's teammates made it easier to relax and to give more attention to the task at hand. Note the similarity between these responses and some of those made to Question 1.

$G_{15}S_2$: I had seen them before. It allowed more attention to be given to the task.

$G_{22}S_4$: I liked it. I could pick my nose etc. without being rude. And I could be rude (verbally) without having to see the person's face (and the hurt look upon it) when I wanted to make a point.

$G_{24}S_2$: That was the major difference. It was good in that you didn't appear rude if you kept disagreeing with someone, or on the other hand it curtailed what you could express.

$G_{24}S_3$: It was good because when we got into arguments it kept one from blowing up.

By contrast, 11 subjects thought that not seeing one's partners may have made it more difficult to get their personal reactions and therefore harder to solve the problems.

$G_{13}S_1$: I would have preferred to see the reactions of my partners to each individual item on the list, and not just to hear their opinions.

$G_{13}S_2$: Their opinions did not seem as important on the personal level. I felt I was going by the value of what was said more than anything else.

$G_{13}S_3$: ...However, it might have been useful to see people's faces to see whether they were really reluctant about a decision, rather than just guessing from their voices.

4. To the question, "IF YOU HAD BEEN ABLE TO SEE ONE ANOTHER, WOULD YOUR TEAM HAVE HAD AN EASIER TIME COMING TO AGREEMENT?" 8 answered "yes" and 19 answered "no." Three subjects mentioned that seeing one another write things down in common view or pointing at the working papers themselves would have been helpful during the conferences. Comments by others related to easing the organizational order of who speaks after whom, to picking up little nuances concerning disagreements or facial expressions, to being less formal and allowing better expression of one's point of view.

5. Twenty-one subjects answered "yes" to the question, "IF THIS KIND OF TELECONFERENCING SYSTEM WERE MADE AVAILABLE TO YOU FOR COMMUNICATING OVER LONG DISTANCES, DO YOU THINK YOU WOULD USE IT?" twelve of these subjects said they would use a televoice conferencing system because it is: similar to a telephone system, simple, effective, and usable over long distances at relatively low cost. Two subjects indicated they would use it because it is almost as effective as meeting face-to-face, while 5 others like using this teleconferencing method for groups of three or more people.

Three out of those who answered "no" to the question wanted to see their fellow teammates in conference; the fourth indicated the desirability of having visual aids.

$G_{24}S_3$: For business conferences, charts, maps etc. are often needed and it is a hindrance not to be able to physically point out things.

Two subjects indicated their choice of a teleconference system would depend upon the particular situation.

$G_{23}S_3$: It would depend on the situation and what I wanted to discuss. If I personally wanted to convince someone of something I would rather be face-to-face. In an open exchange of ideas, yes, I would use it.

6. When asked, "IS THERE ANYTHING ABOUT THE MANNER OF COMMUNICATING WHICH YOU WERE ALLOWED TO USE IN THIS EXPERIMENT WHICH YOU WOULD LIKE TO SEE CHANGED IF YOU WERE USING IT IN AN OFFICE OR YOUR PLACE OF WORK?" 7 subjects suggested adding a video screen for seeing their partners' faces. One of these subjects also suggested using the video to show charts, pictures etc. during the conferences.

Of the remaining 20 subjects, 4 made suggestions that pertained only to modifications of the microphone set-up used in the experiment so that they would have to be less conscious of its directionality. Their suggestions included the use of less directional and more sensitive microphones and modification of the placement of the mikes in the room. These suggestions are oriented more toward the mechanics of "how" to design a televoice system rather than whether or not to do so.

Finally, one subject said he would like to know his partners better before conferencing with them and that he would also like to incorporate a writing capability into his communication system since he believes that written words can sometimes convey a more exact meaning than do spoken words.

Telecommunication mode: Teletype. 1. In response to the question, "WHAT DID YOU LIKE ABOUT COMMUNICATING THIS WAY?" the teletype mode

was described as being new, interesting, challenging, fun, monotonous, clear, concise, logical, direct, business like and to the point, and as providing sufficient time to think between responses before communicating. Eleven subjects liked the conciseness, directness and efficiency of typewritten messages.

$G_{10}S_3$: It made our messages concise. We attempted economy of words and phrases. This way our personalities did not hinder communication as much as they might if we were face-to-face or, to a lesser extent, talking on the telephone. Also, the interruption of messages is more readily respected in this medium.

$G_{12}S_1$: I thought it was kind of challenging because we tried not to waste words and could be imaginative (creating a system of lettering the choices, for example). ,It was fun.

$G_{12}S_3$: It leaves you with a written record of the communication which you can re-hash in your mind. Thereby making communication a bit more efficient (No. of words/idea). It also makes you be a little stricter in choosing your words since you have less of an opportunity to communicate.

$G_{19}S_3$: It was clear. Clearer that is than voice. Also, nobody could dominate because of natural speaking ability, rather, all had to put opinions in.

Five subjects made the point that the design of the system contributed to an orderly transmission of messages and to the availability of a hard copy record.

$G_{10}S_1$: It made available a permanent record of what had gone before.

$G_{11}S_1$: Only one person could communicate at a time. It was very orderly.

$G_{21}S_3$: First, only one could "speak" at a time. Second, it was easier to look up what had been previously relayed; you must think about what you "say" before you "say" it.

Three subjects commented on the reduction (or elimination) of some of the emotionality that would probably have occurred in the discussions.

$G_{19}S_4$: No one could shout.

$G_{21}S_2$: A lack of violent arguments. In session 2 we would have had a good rumble.

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CONFERENCING AND TELECONFERENCING IN THREE COMMUNICATION MODES --ETC(U)
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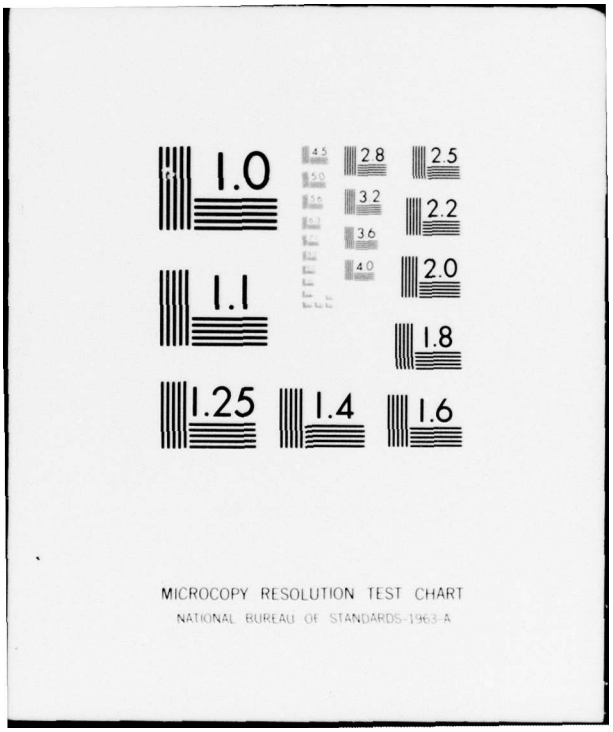
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2. In answer to the question, "WHAT DIDN'T YOU LIKE ABOUT COMMUNICATING THIS WAY?" 16 subjects expressed some dissatisfaction with how long it took them to communicate via teletypewriter.

$G_{12}S_3$: It was a little slower in getting your ideas out, but I suspect that it would take just as long to do the problem if you communicated lots, say by phone.

$G_{19}S_2$: It is often much easier and faster to express oneself in spoken words.

$G_{20}S_4$: Very confining - very little expression is possible, and it takes a long time to say very little.

$G_{21}S_2$: Slowness and a difficulty thinking and typing at the same time.

$G_{21}S_3$: I prefer to look at someone when I communicate. Also, long-windedness takes much more time.

Nine subjects showed some concern over their inability to express themselves adequately over the teletypewriter channel.

$G_1\ S_1$: Couldn't retract statements compared to "eye-contact" communication. It took longer to get the message across, to convince the other person etc.

$G_{11}S_3$: The remoteness made it such that one could not use expressions or even tone of voice to emphasize important points. Also I type very slowly and it seems that something is lost in the communication.

$G_{11}S_1$: I felt confined. I couldn't always say what I felt when I felt it.

$G_{12}S_2$: I had to be patient about cutting in to argue with someone else's point. Sometimes it was frustrating not being able to say exactly what I wanted.

$G_{21}S_1$: Very little intangible information could be communicated.

Twelve subjects cited their own inadequacies as typists and the limitations of the typewriter keyboard as restrictions.

$G_1\ S_2$: No way to correct or emphasize specific words. By emphasize I mean underlining or the like.

$G_{20}S_1$: I'm a terrible typer (zero skill) and that kept me from saying everything I wanted to.

3. When asked, "WAS IT A DISADVANTAGE NOT TO BE ABLE TO TALK TO ONE ANOTHER AS YOU NORMALLY COULD, SAY OVER A TELEPHONE?" 18 subjects indicated that it was.

$G_{11}S_2$: You can't hear how they are saying what they're saying.

$G_{11}S_3$: I vary tones of voice to emphasize points, and can usually tell much about the sincerity of the individual I am dealing with from his voice.

$G_{12}S_1$: I think a little; I tried to be as clear as possible in presenting a point. I might have shied away from some points because they would either take too long or would be easily misunderstood.

$G_{19}S_3$: Only in that it was slightly slower.

$G_{19}S_4$: Yes, but it prevented a person with a big mouth and loud voice from taking over.

On the other hand, 8 subjects stated that not being able to talk *seemed to work to their team's advantage.*

$G_{10}S_2$: Not really. I think it probably helped cut down a lot of unnecessary talk. We only "spoke" at length when we seriously disagreed.

$G_{12}S_3$: No, this caused us to think a lot more before we communicated.

$G_{20}S_1$: No, I got to enjoy "talking" through the teletypewriter.

$G_{21}S_1$: I think it was an advantage in that it forced us to remain analytic and not get only involved in details.

4. When asked, "WAS IT A DISADVANTAGE NOT TO BE ABLE TO SEE ONE ANOTHER AS YOU WOULD IF YOU WERE SITTING FACE-TO-FACE AROUND A CONFERENCE TABLE?" the responses were almost evenly divided: 14 subjects did not think it was a disadvantage, 13 subjects thought it was.

$G_{10}S_2$: No, it was not and it may have been somewhat of an advantage as in that all you knew about the other guy was what he said. You didn't make any value judgment about him based on his appearance.

$G_{20}S_1$: For me, because of my typing skill it was; but for most people I would say no. I do feel we reached a consensus faster by using the machines.

$G_{11}S_3$: Yes, gesticulations and facial expressions seem important to me when I'm trying to communicate or understand a person.

$G_{12}S_1$: I think so, we couldn't tell reactions until we'd finished explaining and then got the response. If we'd seen each other, we'd have gotten this response right away and wouldn't have wasted words.

$G_{19}S_1$: Could not see facial expression. Made one tend to be more conservative, more willing to comply with the group.

5. To the question, "IF YOU HAD BEEN ABLE TO SEE AND TO TALK TO ONE ANOTHER. DO YOU THINK YOUR TEAM WOULD HAVE HAD AN EASIER TIME COMING TO AGREEMENT?" 13 answered "no," 11 answered "yes" and 3 gave both a yes and no answer.

Those who replied in the affirmative generally suggested that more elaborate explanations of one's viewpoint could quickly be made orally and that understanding of another person's position would be enhanced through facial expressions and voice intonation.

Those who replied in the negative generally pointed out that longer, more elaborate conversations would not necessarily have changed the decisions but would have undoubtedly required delving into more points of view and perhaps even a longer decision making time.

6. Twenty-one of 27 subjects answered "no" to the question: "IF THIS KIND OF TELECONFERENCING SYSTEM WERE MADE AVAILABLE TO YOU FOR COMMUNICATING OVER LONG DISTANCES, AT COSTS NO HIGHER THAN AVERAGE TELEPHONE CALLS, DO YOU THINK THAT YOU WOULD USE IT?" twelve of the 21 gave slowness and impersonality as their reasons for not wanting to use the teletype.

The five subjects who said they would use a teletypewriter system pointed to the forced orderliness of conversations and the provision of a hardcopy of the discussion as being worthwhile advantages.

7. When asked, "IS THERE ANYTHING ABOUT THE MANNER OF COMMUNICATING WHICH YOU WERE ALLOWED TO USE IN THIS EXPERIMENT WHICH YOU WOULD LIKE TO SEE CHANGED IF YOU WERE USING IT IN AN OFFICE OR YOUR PLACE OF WORK?" 15 subjects offered no suggestions for modifications. Two of these repeated that they wouldn't want to use the teletype (see above). Of the 12 who offered suggestions for changes, 3 asked for the addition of a video channel, 2 for the use of a trained secretary/typist to operate the equipment for them, and 2 for some mechanical means of correcting typographical errors before they are transmitted. The others essentially desired some means of speeding up the communication process.

Group Size. 1. When asked, "DID YOU LIKE WORKING ON A CONFERENCE TEAM OF THIS SIZE?" 75 of the 81 subjects answered "yes," one subject

didn't answer the question and five answered "no."

Of the "no" answers, one member of a 3-man face-to-face group indicated that he thought the group was "too small." A member of a 3-man televoice group cited the "odd-man-out" idea, namely, the formation of a two-person coalition against the third single participant. For that reason he would have preferred to have the group increased to four.

Three of the "no" responses came from members of 4-man televoice groups:

$G_{22}S_2$: The size sometimes inhibits some of its members from participating.

$G_{22}S_3$: When there were 2 for and 2 against, one side arbitrarily won.

$G_{23}S_3$: Too many disagreements, one person's opinion could take too much time to change or alter.

In general those who belonged to 2-man groups, in each of the three modes, felt that two conferees provided for a quick exchange of ideas and made decision making easy. The 3-man team members frequently cited the usefulness of having a tie-splitting vote on issues and also described their team size as being a comfortable one. Members of 4-man groups described their teams as being large enough to get a diversity of opinions on the issues being discussed but not too large to preclude anyone from having his say.

$G_9\ S_1$: More open to compromise than larger team; easier to agree, lack of filibustering, etc. (Depends on the partners to a large extent).

$G_5\ S_2$: More than 2 people have too many opinions to be agreed upon.

$G_{12}S_2$: Three people is good in that with only two you don't get enough views, and with four it would be harder to come to agreement.

$G_{13}S_1$: It allows for a majority opinion without having very many differing viewpoints to reconcile.

$G_{20}S_4$: It is a good workable group--large enough for enough opinions, small enough to permit discussion.

$G_{21}S_2$: It seemed to work well and there was enough opinions to discuss but not too many to slow things down.

$G_{27}S_2$: Not too large to be heard yet large enough to get diverse feedback and to be able to get strong feeling from someone on everything.

2. In response to the question, "IF YOU WERE ASKED TO SOLVE SIMILAR PROBLEMS AGAIN, USING THE SAME COMMUNICATION MEDIA, WOULD YOU PREFER TO WORK ON A BIGGER OR A SMALLER TEAM?" 59 of 81 indicated a preference for retaining the same group size. Sixteen subjects preferred a bigger group; 6 of these were members of 2-man groups, 4 of 3-man groups and 6 of 4-man groups. Eleven of the 16 expressed a preference for a larger group so that there would be more diversity of opinions within the group.

Five subjects would have preferred a smaller team; 3 of these, all members of 4-man televoice groups expressed interest in having fewer disagreements in the group and having an odd number of conferees in order to provide a tie-breaking vote.

The reasons for retaining the same team size were diverse.

G_4 S_2: Larger team would make reaching agreement harder and more time consuming - a possibility of feeling left out. A possibility of one person dominating.

G_5 S_2: Two conflicting ideas can be resolved easier than three or more.

$G_{10}S_1$: A bigger team would never come to a consensus. A smaller team would be just two people, and hence would not have a tie-breaker vote in case of disagreement.

$G_{21}S_4$: Just enough of a differing opinion to make it interesting and small enough to reconcile those differences.

$G_{17}S_2$: Discussion was free and less inhibited than in a larger size group.

3. In answer to the question, "DO YOU FEEL THAT YOU COULD HAVE REACHED SOLUTIONS MORE QUICKLY IF YOU HAD MORE OR LESS TEAM MEMBERS?" most subjects agreed that solutions should be reached more quickly the smaller the number of conferees. However, some members of 2-man groups suggested that increasing the number of conferees would have helped to give more diversity of opinion, and even though a solution would take longer, the solution could have been a better one.

Many members of the 3-man groups commented on the tie-breaking feature of that particular group size. After experiencing it they seem to be quite convinced of its usefulness.

Some members of 4-man groups indicated that larger groups might be too large, producing too much talking and inefficiency.

4. The question: "DID YOUR TEAM SEEM TO IMPROVE ITS TECHNIQUES OF COMMUNICATING AFTER WORKING TOGETHER ON SUCCESSIVE OCCASIONS?" elicited "yes" responses from all 27 subjects who participated in teletype conferences, 22 subjects in the televoice conferences and 24 subjects in the face-to-face conferences. The comments seem to fall into two categories.

Many comments described how the group gradually established a "system" or strategy for solving their problems. Several groups began by forming 2 preliminary sets of issues, one for the upper and one for the lower ranks, or 3 sets, one each for the upper, lower and middle ranks. Rank positions were then assigned to the issues within those groups before gradually combining all ten items into a single rank order list. Other groups decided first which items should get the highest and the lowest ranks, and then worked inward toward the middle ranks to establish their list. Still others developed a system whereby each conferee on a team recited the ranks he had assigned to the items in his private opinion poll and then one team member summed these to develop a "first draft" of a priority ranking. This list then was used as the basis for further group discussions.

In addition to the development of these problem solving strategies, teletype teams frequently developed other techniques for improving their problem solving processes, e.g., sets of shorthand coding and abbreviations to refer to each of the items on the list.

G_8 S_1: We came to a more efficient way of evaluating. First deciding on the issues which we were sure of.

$G_{15}S_1$: Everyone seemed less afraid to explain his position. Also, everyone saw that if you weren't agreed with, it was nothing personal.

$G_{26}S_4$: A system or routine was devised after the first session which accelerated our progress.

$G_{21}S_2$: We had a numbering system for the items and our tactics worked out.

$G_{20}S_2$: Lettered each of the issues so we wouldn't have to type everything out. Same with abbreviations. People on the team gave in more easily when they were out-voted.

The other category of comments concern personal skills, such as typing ability, and interpersonal variables, such as persuasiveness. Recognition of some of these variables apparently helped some groups to work more efficiently.

$G_{11}S_3$: Very slightly we realized who was the better typist and let him do most of the typing.

$G_{13}S_2$: It seemed certain of the team members came to assume certain roles in the conversation (i.e., the administrator, who would ask the probing questions, the bureaucrat, who would go down the list).

$G_{16}S_1$: We were a little more open with personal information and opinions but member "C" might have opened up a little more - perhaps the others of us should have encouraged him to do so, but we agreed between the two of us and there seemed no need to do so.

$G_{17}S_3$: We were more amenable to each other's suggestions since we knew which we had to do and how to approach each session. We seemed to improve on time in each session, making a better working relationship. We knew what we had to do and knew that compromise was sometimes essential for completion.

$G_{19}S_2$: By the third session people were much more clearly explaining the reasons behind their opinions.

$G_{22}S_4$: We were more ordered in our communication. We learned who to ignore and who to listen to.

Group size interactions with mode. 1. The question, "WAS THERE ANYTHING, AT ANY TIME, THAT KEPT YOUR TEAM FROM PERFORMING AT ITS BEST?", seems to involve both the variables of group size and mode of communication. An unexpectedly large number of the teletypewriter conferees, 19, answered this question with a "no." Seven of the 8 who answered "yes" cited two items that kept the group from performing at its best: (a) their lack of typing ability and (b) the enforced waiting period required while a teammate completed typing his message.

$G_{12}S_2$: Perhaps the inability to directly respond - had to wait, generally until "speaker" finished.

$G_{20}S_1$: My lack of typing ability, but that was really only a minor hindrance.

Fourteen of the televoice communicators answered the question with a "no" while 13 answered "yes." Six of the 13 thought their groups were not at their best because personal rivalries, dissension, hostility, bias and stubbornness developed between group members. Three subjects felt a need to get to know each other better before they could do their best.

G_4 S_2: Not knowing each other beforehand.

$G_{22}S_4$: In session 2 hostility was evident between team members.

$G_{24}S_3$: Sometimes people were very stubborn (including myself), which slowed us down.

Fourteen of the face-to-face communicators also answered "no" to the question. Of the 13 who answered "yes," three on one of the three-man groups, cited fatigue as the only thing that may have kept them from performing their best. This particular team scheduled two out of its three sessions at 9:30 A.M., the first test period of the day. The other 10 subjects who responded "yes" gave a mixture of reasons, e.g., not knowing each other well enough, detecting personal prejudices on the part of some group members toward one or more of the issues being discussed.

2. The subjects were asked: "HOW WELL WERE YOU ABLE TO DETERMINE IF YOUR PARTNER(S) WERE INVOLVED AND PARTICIPATING?". The determination of the degree of participation of one's partner in the 2-man groups was easy. For many of them the answer was simply: by the amount of interacting his partner brought about. However, these determinations were more elaborate and more difficult in the 3- and 4-man teams. In general, subjects in the teletypewriter conferences determined participation on a basis of the frequency and the quality of their partners' responses.

$G_1\ S_1$: By the sincerity of his arguments. He seemed to have good reasons for his proposals.

$G_2\ S_2$: Rather easily. His response time was usually quick and our output is not discontinuous in theme.

$G_3\ S_2$: Pretty well, we had arguments going back and forth.

$G_{10}S_3$: On one level fairly well: by the number and kinds of critical statements. On another: if we don't see them how do we really know it's them communicating rather than someone or something else? This could bother people.

$G_{21}S_2$: Pretty much by what they said not how much they said. What they said showed if they were "listening."

$G_{20}S_2$: By their attempts to get the "line," by what they said as to how much thought they gave an issue.

Subjects who communicated in the televoice mode generally judged partner participation by the amount of discussion and by the confidence of opinions expressed.

$G_6\ S_2$: If he said something after I said something, he was participating.

$G_{13}S_2$: They both seemed rather enthusiastic about arriving at the conclusion.

$G_{14}S_1$: Rather well. One could easily recognize whether a partner was blindly following or expressing definite reasons for agreement or objection.

Participation was most easily determined in the face-to-face mode. Seventeen subjects said they were able to do this easily and gave answers such as "very well," "pretty well" and "extremely well." Some of their descriptions follow.

G_9 S_1: Extremely well - decisions were made jointly.

$G_{17}S_1$: Sometimes I could see someone throwing in the towel at a point. I felt that it was pretty easy to see when the other two were tired of the agreement reaching and wanted to end the whole thing.

$G_{25}S_3$: Very well, as far as strength of opinion expressed.

$G_{27}S_2$: By their suggestions and emotional delivery.

3. Response to the question, "HOW WELL DID YOU GET TO KNOW THE OTHER STUDENTS BY COMMUNICATING WITH THEM IN THIS EXPERIMENT?", suggest that most subjects didn't get to know each other very well at all. Only five televoice subjects said they got to know their partners well and even these opinions were qualified with remarks that they only learned things about how their partners thought, something about their biases and attitudes and some of their values. Eight of the face-to-face conferees and 7 of the teletypewriter conferees made similar comments about how well they thought they got to know their partners.

G_4 S_1: I don't think an experiment of such short nature as this really provides any insights into another person. About the only thing I found out about my partner is that he is passive.

G_7 S_1: I didn't get to know him that well, although I could anticipate many of his responses.

G_8 S_1: Before the experiment I didn't know my partner. Now we know each other rather well and I imagine the end of the experiment will not end our friendship.

$G_{10}S_2$: Well enough to get a general idea of their approach to the issues. Who was well organized or well thought out became clear.

$G_{15}S_1$: Not really very well. Couldn't tell anything about them except how they reacted to people and what they thought about the topics questioned.

$G_{19}S_2$: Not too well, communicatien was too businesslike to get to know people well.

4. The last question asked: "IN GROUP DISCUSSIONS LIKE THESE, SOMETIMES A 'LEADER' OR A 'CHAIRMAN' EMERGES. IN EACH OF THE SESSIONS DID THERE SEEM TO BE A LEADER? IF SO, WHO WAS IT?" Less than half of the subjects reported any emergence of leaders on their teams.

Those who did report the emergence of a leader characterized him as either an organizer or the decision-maker. The organizer usually established the rules of procedure that were followed by the group in its problem solving process. He typically solicited opinions from the group members and called for a decision when the time was right. In short, the organizer was viewed as having led the discussions and as having done most of the talking.

The leader who was a decision-maker usually did a lot of talking too. But he presented the most persuasive arguments for ranking issues one way or another. He spoke with more authority and in some cases was even described as having been a bit stubborn.

There were no obvious relationships between responses to this question and either group size or communication mode.

Summary

Nine groups of 2, 3, and 4 students each, 27 groups in all, discussed stimulating topics in face-to-face conferences or in one of two teleconference modes: teletype and televoice. Each group used one of the three communication modes to solve a different problem on each of three days. The problems elicited opinionated discussion and required the students to arrive at a consensus about how their fellow students felt regarding (a) the priority of certain national issues facing the country today, (b) the allocation of university resources to various budgetary categories, and (c) financial support of diverse student activities on campus. Performance was assessed on a number of dependent measures: time to solution, the number of messages and of words exchanged by the team, the number of messages and of words used by the average conferee, message length, communication rates measured by the numbers of messages and of words communicated per unit time, disparities among the numbers of messages and words used by conferees within a group, and the agreement between the consensus arrived at by the team and a group norm. Finally, all participants completed a questionnaire soliciting their opinions about several features of these conferences.

The most interesting, and novel findings of this experiment concern the effects of group size and communication mode on the performance of groups and individuals. Following is a summary of the most important findings:

1. Mean time to arrive at group consensus did not change appreciably as group size increased nor did mean times to solution change as the groups acquired experience working together on three successive occasions.

2. The average numbers of messages and of words generated by the groups increased in a linear manner as the number of conferees increased. On the other hand, the average numbers of messages and of words per person were constant and independent of group size. It is as though each additional person brought about a constant increase in the amount of communication irrespective of the number of other people in the conference. All these findings are robust and hold for all problems, modes, and days of test. Interactions among these variables are few and those that are statistically significant are not of great practical importance.

3. Communication rates, measured both by the numbers of messages and of words communicated per minute, increased linearly as the number of conferees increased. A significant interaction between group size and modes for the numbers of messages communicated per minute shows that the increase in communication rates was much greater for the two voice modes--face-to-face and televoice conferencing--than for teletype conferencing.

4. Message lengths, or number of words per message, were significantly greater for the 2-person groups than for either of the larger groups. This effect was not particularly large. There were no significant interactions involving group size on this dependent variable.

5. Members of 2-person groups tended to share almost evenly in the number of messages produced. The larger groups, however, showed a significant increase in the disparity among the numbers of messages produced by the conferees. That is, one or two members seemed to dominate their teammates by producing more messages, whereas other teammates tended to produce correspondingly fewer messages. These are robust findings since there are no significant interactions between this variable and any of the others.

6. Groups that conferred by teletype took over twice as long to reach consensus agreements, on the average, as did those that conferred by televoice, and over one and one-half times as long as those that conferred face-to-face. This is a robust finding that holds for all group sizes, problems, days, and all combinations of these variables.

7. Groups that conferred face-to-face produced one and one-half times as many messages and words as did those that conferred by televoice and over five times as many messages and words as those that communicated by teletype. Groups working in the televoice mode used over three times as many messages and four times as many words as those that used teletype. When the data are converted to numbers of messages and words per person, essentially the same findings hold. The almost complete absence of any interactions involving modes shows that these findings are strong and hold

for the several group sizes, problems, days, and virtually all combinations of these variables. Taken together, these findings show that the voice modes of communication are faster but very much wordier, no matter how you measure wordiness, than is the teletype mode.

8. As might have been expected, communication rates in the two voice modes were considerably greater than in the teletype mode. Communication rates for the face-to-face conferences were very nearly equal to those for the televoice conferences. As noted in 3 above, communication rates increased sharply in the two voice modes as the number of conferees increased. Communication rates increased much less in the teletype mode. There were no significant interactions involving these variables.

9. Conferees in the teletype mode tended to produce more nearly equal numbers of messages than did those in either of the two voice modes. There is some suggestion here, then, that the teletype mode of communication tends to be more equalitarian than does either of the two voice modes.

10. There were only a few significant effects attributable to days of test. These generally show that both groups and individual conferees tended to use somewhat fewer words in successive problem solving sessions. In addition, there was a small but statistically significant tendency for the various group members to share more evenly in the production of messages in successive sessions. Although differences among mean message lengths were statistically significant, they do not form any regular trend from session to session. Taken as a whole, the effects attributable to days of test were very much smaller than those attributable to communication modes and group size.

11. There were only a few small effects attributable to problems. Students tended to use slightly shorter messages in solving problems more directly related to their immediate interests and campus experience (the University Budget and Student Activities Budget Problems) than in arriving at a consensus about a problem of less immediate impact (the National Issues Problem). As measured by a group norm, students were also able to arrive at a better consensus agreement about the two university-related problems than about the National Issues Problem.

12. As measured against a group norm, consensus decisions arrived at by the groups were neither significantly better nor worse as a function of group size, mode of communication, or successive work sessions. Although the teletype mode of communication has several disadvantages, it does not appear to have any appreciable effect on the quality of decisions. Nor is there any evidence here that larger groups affect the quality of decisions.

13. The questionnaire produced a large number of opinions. The strongest single finding was a general dissatisfaction with the teletype as a mode of communication.

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